REPORTS OF THE EXPEDITION TO THE CONGO 1903-5

LIVERPOOL SCHOOL OF TROPICAL MEDICINE—MEMOIR XVIII.

REPORTS OF THE EXPEDITION TO THE CONGO, 1903-5

BY THE LATE
J. EVERETT DUTTON, M.B. VICT.
AND
JOHN L. TODD, B.A., M.D., C.M. McGILL

WITH
DESCRIPTIONS OF TWO NEW DERMANYSSID ACARIDS
BY
ROBERT NEWSTEAD, A.L.S., F.E.S., ETC.

AND
THE ANATOMY OF THE PROBOSCIS OF BITING FLIES
BY
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AND
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PREFACE

The reports of the Congo Expedition which are contained in this volume embody the results of the most important pieces of work in progress at the time of the much deplored death of the head of our Expedition. It is impossible to tell how much the friend in him was regretted; how much the leader was missed. Our loss was great and the work of the Expedition suffered severely.

Dr. Dutton had been my companion through three years of constant work on trypanosomiasis. We knew each other's ideas most thoroughly and since the work was continued after his death, along the lines we had planned out together, I feel justified in ascribing to him joint authorship in these reports. May the way in which his name is used be remembered, and weakness in presentation of our results be recognised as mine and not considered in any wise as a fault of my absent comrade.

Sincere gratitude is due from our school to every person in an official position with whom our Expedition came in contact during its two years' absence from England.

The Compagnie Belge Maritime furnished free passages to and from the Congo. During the voyages, at Sierra Leone and at Boma its agents rendered every aid in their power.

It is quite impossible to sufficiently express our indebtedness to the Congo Free State Government and to its representatives. From highest to lowest, each official did all in his power to ensure the success of our work. What success we have obtained is largely due to their intelligent sympathy and generous co-operation.

From missionary societies of all denominations and from the representatives of the Comité Special du Katanga and the firm of Hatton and Cookson, aid and hospitality were constantly received. We gratefully acknowledge our indebtedness.

Those who served on this expedition received constant cause for gratitude from the members of the Committee and Staff of our School. This opportunity is taken to express our appreciation of their sympathy to the Chairman and Committee, to Professor Ronald Ross, Dr. J. W. W. Stephens, Mr. Robert Newstead, to the Dean of the School—Professor Rubert Boyce, and to Dr. H. E. Annett.

PREFACE

While we were working in the Congo the more strictly laboratory side of our common work was studied by Dr. H. Wolferstan Thomas and Dr. Anton Breinl. Much is owed to their constant co-operation.

Lastly, it is pleasant to acknowledge a personal debt of gratitude to Dr. Inge Heiberg, Medicin du 1ère classe de l'Etat Independant du Congo.

Dr. Heiberg was attached to our Expedition by the Free State Government when we first arrived in the Congo. He remained with us throughout our stay. His sound advice and thoughtful aid made many of our difficulties easy. The memory of his sympathy and comradeship will always remain my happiest souvenir of the Congo. In him was gained a good friend.

Thanks are due to Dr. Annett for correcting the proofs of the report.

J. L. T.

November, 1905.

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GLAND PALPATION IN HUMAN TRYPANOSOMIASIS

GLAND PALPATION IN HUMAN TRYPANOSOMIASIS

Being the Third Progress Report from the Expedition to the Congo, 1903-04-05, of the Liverpool School of Tropical Medicine

BY THE LATE

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AND

JOHN L. TODD, B.A., M.D., C.M. MCGILL

In August, 1904, we wrote reports (1, 2), based on work suggested by a communication of Greig and Grey (3), which led to the following conclusions:—

(1) the examination of glandular fluid, though not infallible, is a very efficient means of detecting the presence of trypanosomes;

(2) by reason of its simplicity, gland puncture will be found a very useful routine diagnostic method, and

(3) we suggested that it might possibly be necessary to consider all natives to be cases of trypanosomiasis who lived in infected districts, and had enlarged cervical glands without apparent cause.

These conclusions were drawn from a comparatively small number of observations and it remained:—

(1) to prove further the superiority of gland puncture over other methods of detecting the presence of trypanosomes (in negroes) and to determine with what constancy the parasites might be found in the glands of persons known to be infected with trypanosomes, and

(2) to decide what reliance should be placed upon the presence of glandular enlargement (in negroes) without any obvious cause, as a diagnostic sign of trypanosomiasis.

I. Gland Puncture.

The examinations upon which this paper is based were made at various points along the route of our Expedition, indicated on the accompanying map. Some of the patients came from localities which had suffered greatly from trypanosomiasis, others from districts in which the disease was entirely unknown.

Technique.

The technique by which the blood and cerebro-spinal fluid of the following cases were examined have been described in earlier reports (1, 4). Fresh preparations of blood were as usual made with ¾in. square cover-slips, and were examined with a Zeiss D objective and a No. 2 or No. 4 ocular. In every instance the method of centrifugalizing blood mentioned in our first note on gland puncture was that employed (1). As usual, large quantities (to 40 cm.) of cerebro-spinal fluid were centrifugalized and numerous coverslip preparations of the precipitate were examined before registering a negative result.

Though gland puncture is an exceedingly simple operation attention to a few details is necessary for complete success. An ordinary hypodermic syringe,* capable of producing a good vacuum and fitted with a strong but slender needle is required. It will be found of advantage if the nozzle of the syringe fits into the needle, as is shown in fig. 1†, so as to leave a space to receive the drop of gland fluid, usually all that can be obtained. Before being used the syringe should be boiled, washed with sterile salt solution and thoroughly cleared of *all* liquid. If water is allowed to remain in the syringe the movements of the parasites are impaired; if salt solution, the volume of the fluid to be examined is unnecessarily increased.

The accompanying photographs (fig. 2) illustrate a convenient method of making the puncture. The gland to be punctured is lifted and firmly fixed by the fingers of the left hand; the skin covering it is made as tense as possible (*a*). By a quick movement the needle is passed into the gland; the resistance offered by its fibrous capsule is often very distinct (*b*). The plunger is then slowly drawn out to its full extent by an assistant. It is fixed in its extended position by the forefinger of the hand holding the syringe and the needle is gently moved, two or three times, up and down in the gland substance (*c*). The plunger is now allowed to return almost as far as it will, is again fixed by the forefinger and the needle is withdrawn. If the needle were removed from the gland while the plunger was fully drawn out the fluid, usually very scanty, would be blown up into the body of the syringe and much of it lost. Were the plunger unfixed while the needle was withdrawn part of the fluid would be left behind in the patient. The syringe is then held vertically, the needle almost touching a slide, and with one sharp push of the plunger a drop of fluid is forced out (*d*). If two or three movements of the plunger are made the fluid

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* Dr. Breinl has suggested that the employment of syringes furnished, like those for spleen punctures, with rings on barrel and piston for fingers and thumb, would make it easy to do gland punctures without the aid of an assistant.

† See page 11.

a *b* *c* *d*

Fig. 2.

expelled is almost certain to contain air bubbles; in such preparations trypanosomes often remained unseen though they were probably present. A cover-slip is placed upon the gland fluid and a fairly thin preparation made. A minute piece of skin, cut out by the needle, is often contained in the fluid and, unless it is avoided, makes a thin preparation impossible. The preparation should be ringed with vaseline and examined at once. It is, as usual, chiefly by its movements that the parasite is detected. A magnification of about 250 diameters is, therefore, quite sufficient. The parasites may be numerous or very scanty, and since phagocytosis is very frequent the whole preparation must be gone over as quickly as possible. In addition, although some parasites appear quite normal and may survive for several (eight observed) hours, others, in perfectly fresh preparations, are seen to have lost much of their motility and very rapidly become deformed, granular, less refractile and motionless.

The unsuccessful examination of an improperly made specimen, one mixed with water or saline or filled with air bubbles, has no value. Another preparation must be made and a negative examination must not be registered before a perfect specimen, in which the white cells are brilliant and well-formed, has been examined. A small amount of blood is not detrimental. The most successful specimens are not so encumbered with cells as to hide the movements of the parasites, nor are they so thin as to appear watery. As a rule not more than sufficient gland fluid for a ¾in. cover-slip preparation is obtained, but from 20 to 30 drops of watery fluid may sometimes be drawn from large glands.

Apart from faults of technique the following are the most usual causes of imperfect preparations. Occasionally in particularly soft glands and advanced cases of trypanosomiasis, preparations are obtained in which the white cells are unrefractile and degenerated—the whole specimen is glairy or pus-like and rarely contains trypanosomes. Trypanosomes have never been seen in the pus aspirated from glands breaking down from any cause (tuberculosis, venereal disease, etc.). The absence of trypanosomes from a gland in which they should have been found is accounted for in this way in at least one instance in this series of cases (Case 395, see below). Glands, particularly the epitrochlears, were occasionally extremely hard, and it was impossible to obtain any fluid from them.

When the examination of the cases on which this paper is based was commenced, it was frequently found that trypanosomes were not seen in imperfect specimens of juice from glands in which their presence was demonstrated by the immediately succeeding examinations of more perfect

preparations. As experience was gained the searching of imperfect preparations was recognised to be a waste of time, and only perfect specimens were examined. The results obtained from the examination of such preparations only, have been considered in compiling the tables accompanying this paper.

The comparative efficiency of the different methods of demonstrating the presence of Trypanosomes in infected Persons.

The figures given in the tables accompanying this section are based upon the examinations of 250 consecutive cases of human trypanosomiasis, early and advanced ("sleeping sickness"). Table 1 indicates the percentage of successful examinations by each method. The actual number of cases examined in each instance is also noted.

The number of cases in which the blood was centrifugalized is altogether too small to permit of the figures obtained being considered as more than an approximation to the actual worth of the method. For the purposes of comparison we have, therefore, placed in the "BLOOD, Total" column a figure intended to represent the percentage of successful examinations which the centrifugalization of the blood of all the cases in this series might be expected to furnish. This figure was obtained in the following manner:—The 30 cases of trypanosomiasis detected by the examination of cover-slip preparations of blood (Table 1) would certainly have been found by centrifugalizing. They are, therefore, considered as successes; and it is assumed that the same ratio of successful examinations would follow the centrifugalization of the remaining cases as was obtained in the 17 already examined.

The percentages placed in the "BLOOD, Total" column of Tables 2 and 3, have been obtained in a similar manner.

TABLE No. 1.

	BLOOD.			GLAND JUICE.	CEREBRO-SPINAL FLUID.
	Fresh coverslip preparations.	Centrifugalised.	Total.		
Percentage of successful examinations ...	13·6 %	47 %	**54·2 %**	**97·2 %**	**59·6 %**
Number of examinations	220	17	--	250	52
Number of successful examinations ...	30	8	—	243	31

On 17 occasions (7 early and 10 advanced cases) the examination of a first preparation of gland fluid was negative, but a further examination showed parasites. If the table be corrected for each method so as to consider as negative cases in which the first test was unsuccessful but further examination succeeded in demonstrating the presence of the parasites, it will read as follows :—

TABLE No. 2.

	Blood.			Gland Juice.	Cerebro-Spinal Fluid.
	Fresh coverslip preparations.	Centri-fugalised.	Total.		
Percentage of successful examinations ...	13·3 %	41·2 %	**49·2 %**	**90·4 %**	**59·6 %**
Number of repeated successful examinations	2	1	—	17	No second examination was successful.

This estimate of the relative efficiencies of the four methods is not based, in every case, on results obtained by coincident examinations by each of the methods to be compared. A control was, therefore, established in which 17 cases were examined on the same day by each of the methods. The results obtained were substantially the same as those presented above.

We have classed as "Advanced Cases" those persons who were obviously ill when we saw them. They were usually brought to us by Natives or Europeans as having "sleeping sickness." In most instances the disease was easily recognisable clinically, and all would have come under the types designated as "B" and "C" in our Second Progress Report (4). "Early cases" are those, Type "A," in whom no general symptoms were observed by ourselves and the presence of the disease was unsuspected by the patients' friends.

If the 250 cases are divided into these two classes, advanced and early, it is seen that the parasites were more easily found in the blood, and particularly in in the cerebro-spinal fluid, of the advanced than of the early cases of trypanosomiasis.

The following Table illustrates these points :—

TABLE No. 3.

		Blood.			Gland Juice.	Cerebro-Spinal Fluid.
		Fresh coverslip preparations.	Centrifugalised.	Total.		
Advanced Cases.	Percentage of successful examinations ...	**20·6 %**	53·8 %	**57·3 %**	**95·6 %**	**96·6 %***
	Number of examinations	92	13	—	114	29
	Corrected percentage of successful examinations	18·4 %	46·1 %	—	86·8 %	—
Early Cases.	Percentage of successful examinations ...	**8·6 %**	25 %	**31·4 %**	**98·5 %**	**13 %**
	Number of examinations	128	4	—	136	23
	Corrected percentage of successful examinations	No second examination was successful.	No second examination was successful.	—	93·3 %	No second examination was successful.

* Only one negative—otherwise 100 %. The negative case (169) was a boy in the service of Dr. Dye, and therefore under careful observation. When we saw him he was only vaguely suspected of S. S. Certainly there were no gross mental symptoms, and a stranger, seeing the lad for the first time, would have noticed nothing.

It must be remembered that as the majority of these cases were seen but once this division is far from accurate; indeed, it is probable that a longer examination would have recognised obvious signs of disease—fever, wasting or mental derangement—in several of the cases which are classed as "early"; and at least two of the three "early cases" whose cerebro-spinal fluid contained trypanosomes would certainly have been classed as "advanced cases" (Case 382, see below).

Trypanosomes were found without exception in the cerebro-spinal fluid of every patient in this series who had marked cerebral symptoms such as mania,

drowsiness or, most often, a slight mental unbalancing. In only one instance were parasites not found by a single lumbar puncture of a case suspected clinically of "sleeping sickness." This was a boy aged 12 (Case 169), employed as a house boy by a medical man and his wife.* He was under constant observation. There was absolutely no hint of nervous trouble and the suspicion of illness was very vague. An ordinary observer would certainly have perceived nothing abnormal.

As above noted, trypanosomes were (in 23 cases) only three times found in the spinal fluid of the earlier cases—persons apparently well save for enlarged glands. These observations certainly support the idea that the appearance of cerebral symptoms in trypanosomiasis may depend upon the presence of the parasites in the cerebro-spinal fluid.

Gland puncture is, perhaps, not so successful in advanced as in early cases. Five of the seven patients (250 cases) in whose glands trypanosomes were not found were obvious "sleeping sickness" cases. The glands of all the superficial groups diminish in size as the disease advances, and occasionally in the last stage it is difficult to find a gland large enough to puncture. This mechanical difficulty is, however, rarely great enough to be, in itself, the cause of failure. This atrophy of the glands is possibly due to a continuation of the fibrosis described by Thomas and Breinl (5).

Three of the seven failures of gland puncture to show trypanosomes in this series of 250 cases were probably due to insufficient examination (Cases 395, 150 and 165, see below); but as the accompanying extracts of cases show, occasionally the most careful examination fails to demonstrate the presence of trypanosomes in the glands of persons infected by them.

Despite these failures an inspection of Tables 1, 2 and 3 indisputably indicates that **gland puncture is by far the most efficient method of demonstrating the presence of trypanosomes in cases of trypanosomiasis.**

CASE 150 (Advanced trypanosomiasis). July 25th, 1904.

Male, 19, in hospital for "sleeping sickness." Well developed; not emaciated, irritable, frowning, answers questions without interest.

History and Present Condition.—Ill one month, skin dry, face puffy, headache, no tremors, co-ordinations perfect, reflexes slightly exaggerated. Glands all enlarged and easily palpable.

Examinations.—Blood and cerebro-spinal fluid both contained many trypanosomes. Enlarged cervical glands were twice punctured and seven cover-slip preparations of gland-juice were examined. All of them however were "watery" and none were really good specimens.

(*This examination was certainly insufficient.*)

* Dr. and Mrs. Dye, of Bolengi. Our thanks are due to them for the sympathetic aid we received during our stay at their station.

CASE 165 (Early trypanosomiasis). August 1st, 1904.

Female, age 22. Strong, supposedly healthy woman, frequently comes under observation of Dr. Dye, glands all enlarged. Trypanosomes were found in the blood by centrifugalizing.

An enlarged cervical gland was punctured once and two fairly good cover-slip preparations of gland-juice were examined with a negative result.

(A suspected case should be more thoroughly examined.)

CASE 233 (Advanced trypanosomiasis). October 10th, 1904. Female, aged 20.

History and Present Condition.—Recognised by natives as a case of "sleeping sickness," said to have been ill for one month. Spends most of time dozing on mat. Distinctly thin, feeble, weak-minded, tremors. Is a well-marked advanced case of trypanosomiasis. The only group of glands distinctly palpable are those in the neck and they are very small; there are only a couple (size estimated at 0.4 x 0.4cm.) in each posterior triangle.

No trypanosomes were found in the blood (not centrifugalized) nor in the fluid obtained by three punctures made into two glands. Numerous parasites were found by lumbar puncture.

CASE 322 (Advanced trypanosomiasis). October 31st, 1904. Female, age 19.

Present Condition.—(Nature of illness unrecognised by natives.) Well developed and well nourished, complains of headache. Dull heavy expression, eyes prominent, ocular tension increased, no tremors. Glands: all groups very much enlarged.

Examinations.—The blood showed 20 trypanosomes to the cover-slip preparation. The parasites seen were all strikingly long forms.

Four glands from three groups were punctured and six excellent preparations were examined. No trypanosomes were seen.

CASE 344 (Advanced trypanosomiasis). January 20th to February 9th, 1905.

Male, age 16. Has been employed for three years on the station as a bricklayer. During the last two months has become "light headed" and "silly." His companions say that he has "sleeping sickness."

Present Condition.—Looks and acts like an early case of "sleeping sickness"; is thin, excitable; mouth constantly twitches. Glands: cervical, all size of peas; axillary, just palpable; epitrochlear, not palpable; femoral, enlarged—some to 2 x 3cm.; inguinal, size of peas.

Temperature varies between 98-102. P. 88-116; R. 17-28.

Examinations.—Coverslip preparations of this blood were examined on eight days, in addition his blood was once centrifugalized; trypanosomes were never seen. Thirteen good cover-slip preparations of juice taken on four days from different glands of all four groups were examined. Trypanosomes were not seen. Lumbar puncture was done on Feb. 1st and 41ccm. of slightly opalescent fluid drawn off. All the precipitate obtained by centrifugalizing was examined and 14 trypanosomes seen.

CASE 382 (Early trypanosomiasis). May 17th-19th, 1905.

Male, age 23. This man was recalcitrant and as full an examination as we wished was impossible.

Present Condition.—Seems to be a strong healthy man, regularly carries heavy loads over a distance of twelve days' walk. Glands: the epitrochlear was the only group markedly enlarged. The axillary were just palpable, and the inguinal and femoral were, as is so often the case, moderately enlarged. The posterior and anterior cervical and the sub-maxillary groups were not palpable. The epitrochlear glands were punctured but three attempts failed to draw juice from them.

Examinations.—Two good preparations from a femoral gland were negative as was also a cover-slip preparation of the blood. Twenty-one ccm. of cerebro-spinal fluid were drawn off and centrifugalised. Scanty trypanosomes were found in the precipitate.

CASE 395 (Advanced trypanosomiasis). November 9th, 1904. Male, age 23.

Present Condition.—Recognised as a case of "sleeping sickness" by the natives; has lost flesh but is not distinctly emaciated, can scarcely walk; intelligent, answers questions but is rather slow; no tremor, reflexes not increased. Glands: none are palpable in the neck, or epitrochlear regions;

one or two small ones are felt in the axillæ; the femoral and inguinal groups are enlarged and freely movable.

Examinations.—A gland of the femoral group was punctured and pus-like fluid, which contained no trypanosomes, was obtained. *This examination was very insufficient.* No parasites were found in a cover-slip preparation of the blood. Lumbar puncture was done and 4 ccm. of cerebro-spinal fluid obtained which contained many trypanosomes.

To determine whether trypanosomes might be found with equal facility in the glands of any superficial group of an infected person, preparations of the juice of glands of the posterior cervical, axillary, epitrochlear and femoral groups were examined in a series of 20 cases of trypanosomiasis—13 early and seven advanced.

The result is indicated in the accompanying Table:—

TABLE No. 4.

	Post Cervical.	Axillary.	Epitroch-lear.	Inguinal and femoral.
Percentage of successful examinations	95 %	90 %	65 %	80 %

Substantially the same result is obtained by calculating the percentage of successful examinations of glands from the various groups of the 250 cases, about a third of whom were punctured in two or more groups (see Table 5). The total number of cases examined is given and, as in Tables 2 and 3, are modified by considering as failures cases in which a second examination was necessary to detect the parasites.

TABLE No. 5.*

	Post cervical.	Axillary.	Epitroch lear.	Femoral.
Percentage of successful examinations	94·9 %	87 %	54·2 %	72·2 %
Number of examinations ...	236	54	24	72
Corrected % of successes ...	91·1 %	87 %	37·5 %	64 %

* Glands belonging to the anterior cervical triangles were punctured on three occasions. Trypanosomes were seen each time.

Enough observations have not been made to permit definite assertions, but these figures seem to support Greig and Grey (3), who concluded that the parasites were most easily found in the neck glands. We are inclined to think that this difference may be less real than the figures indicate. The posterior cervical is certainly the group most conveniently punctured. However, parasites were absent, at repeated examinations, from the neck glands of six patients in this series of 250 cases, but were found in other groups.

If there is any difficulty in finding trypanosomes in the cervical glands of a suspected person, preparations from every group should certainly be examined.

In this series of cases negative examinations of glands were in 26 instances immediately followed by second examinations with a successful result. In 13 cases the first preparation had been faulty, in the remainder each preparation has been perfect. It is obvious that in a suspected case a second examination should be made if the first, even though the specimen be perfect, is negative. Our observations are not complete enough to decide whether trypanosomes may disappear from glands in which they have once been found as they do from the blood stream. It seems possible that they may do so, although as a rule their presence is constant. Fourteen glands in all, belonging to nine cases of trypanosomiasis were examined twice at intervals of from three weeks to two months. In only three instances were parasites absent at one examination and present at the other.

Both sheathed and unsheathed *Filariae* may be seen in gland juice, but they are much more easily found in the blood.

We have at present nothing to communicate concerning the morphology of the parasites found in the glands or concerning the changes they there undergo.

II. Glandular Enlargements an Index of Trypanosomic Infection.

Having verified our former results and satisfied ourselves that parasites could be found in the glands of almost every case of human trypanosomiasis, we endeavoured to determine what percentage of natives living in infected districts and having glandular enlargements from no apparent cause, were cases of trypanosomiasis.

Our method was as follows:—In each village examined we went from hut to hut palpating the cervical region of every native man, woman or child that we saw.

The posterior cervical group was at first chosen for routine examination because it is the group most conveniently palpated; it is the group least subject to the ordinary causes of lymphatic enlargement, particularly trauma; and

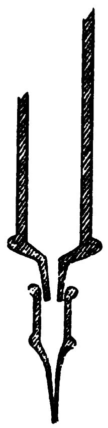

FIG. I

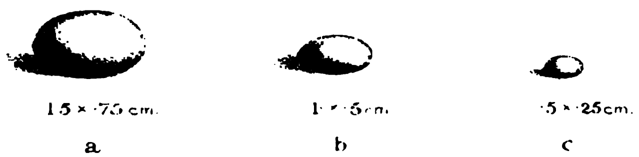

FIG 3

because Greig and Grey (3) had stated that parasites were most easily found in these glands. Later it was found that the posterior cervical group might properly be taken as an index of the general glandular enlargement which, as is shown below, occurs in trypanosomiasis. Fig. 2 (*c*) indicates the position in which large glands are most frequently found in the posterior cervical triangles. They lie just in front of the anterior border of the trapezius. Occasionally the whole triangle is literally filled with large glands. More usually three or four middle-sized glands (diameter 1 cm.) lie at the base or one or two smallish glands are at the extreme apex of the triangle.

According as the posterior cervical glands of natives palpated were much enlarged, slightly enlarged, very slightly enlarged or not palpable, they were styled "+", "+ –", "+— –", or "–". At first our only aim was to pick out persons with enlarged glands and those examined were placed in one of two divisions according as enlarged glands were present or absent. As we became more experienced our classification became more precise, and we endeavoured to make our "+" signify "persons in whose glands trypanosomes are almost certain to be found."

The following empirically-formulated classification defines the values finally given to our working terms. The measurements given refer always to the estimated length and breadth of the glands:—

Cases with great enlargement of the post-cervical glands were classed as "+". To come under this heading it was necessary that there should be in each posterior cervical triangle at least—

(*a*) one gland whose size was estimated at 1.5 × 0.75 cm. (fig. 3*a*).

(*b*) several (3 or more) smaller glands, the largest measuring perhaps 1 × 0.5 cm. (fig. 3*b*).

Groups showing less enlargement than this but more than "+——" were classed as "+—".

As "+——" we classed groups containing—

(*a*) only one or two glands measuring 0.5 × 0.25 cm. (fig. 3*c*), or

(*b*) many tiny, usually hard and shot-like glands, which were only just palpable.

Those persons were classed as "—" whose posterior triangles contained no palpable glands.

Mistakes are bound to occur in the application of such a classification. For example, in persons with short, fat, heavily-muscled necks it is very difficult properly to palpate the posterior cervical glands, and the personal element must play a part in the observer's estimation of the size of the glands.

As we mentioned above, our cases were not at first so carefully classified. "Enlarged Glands" only were looked for. For the purpose of this report all our cases were, therefore, re-classified, as far as our records permitted it, according to our final system. It was, however, frequently impossible to make any alteration, and "Enlarged Glands" were then necessarily classed in the same category as our "+" cases, thus many cases are placed under that heading which should certainly have been called "+—" and "+——".

Our gland palpations are, therefore, divided into two parts, the first for the first two months during which gland palpation was employed, the other for the succeeding ten months. The result of this unfortunate lack of uniformity in standards will be plainly seen.

Table 6*.—**From August to October, 1904, persons with "enlarged glands,"** sometimes only small ones, were considered as "+". As a result only half of the "+" cases were found to be infected, and no infected persons occurred in either of the other groups. From October to July, 1905, the final standards described above were employed. Many cases which were formerly classed as "+" were classed as "+ –"; as a result 90 per cent. of the "+" cases were shown to be infected, but eleven infected persons are found in the "+—" division. It seems from this result that our standard for "+" cases is slightly too high; had it been somewhat lower our records show that all these eleven infected cases would have been admitted to that class. There was in each of them more or less of a general glandular enlargement.

Two facts are irresistibly suggested by these figures:—

(1) In the great majority of cases **"enlarged cervical glands,"** in the apparently healthy negroes examined by us, *mean trypanosomiasis*.

(2) Unless the glands of apparently healthy persons were enlarged, juices from them did not contain trypanosomes.

The truth of the first postulate becomes even more evident when it is remembered that practically all these cases were examined but once, and that, as was shown in the first part of the paper (Table 2), we must expect to fail to find trypanosomes in 9.6 per cent. of even known cases examined under such conditions.

Only apparently healthy persons have been considered in compiling Tables 6, 7 and 8; all were omitted who showed any obvious clinical signs of trypanosomiasis or had causes such as dirty skins (craw-craw, yaws), or dirty scalps (seborrhœa, cuts, lice), to which their enlarged glands might be ascribed. It may be noted here that a very large percentage of natives in the Congo have some small degree of pyorrhœa alveolaris. The mouths of advanced cases of

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* See page 19.

trypanosomiasis are usually disgustingly foul. As a result the sub-maxilliary glands are very often found to be much enlarged.

Twenty-six of the persons thus excluded from the tables because of obvious causes for their enlarged glands were nevertheless examined: eight of them were found to be infected.

It is, therefore, suggested that in heavily infected districts all persons with generally enlarged glands must be suspected, without exception, of trypanosomiasis.

Interesting conclusions are reached by a study of the records of careful palpation of all the superficial gland groups in nearly all of the 585 persons punctured (445 apparently healthy natives, 114 cases of "sleeping sickness," and 26 persons with skin disease). It is at once seen that, as a rule, the glandular enlargement of patients suffering from trypanosomes is general and that it is usually more pronounced in early than in advanced cases. Forty-five of the 114 advanced cases of trypanosomiasis punctures had glands whose enlargement was less than "+". Both these points are confirmed by a reference to our records of cases of trypanosomiasis detected by the examination of blood or cerebro-spinal fluid and observed either in the Gambia (6), or in the Lower Congo (4).

In a few instances a marked diminution in the size of the glands has been noticed in advanced cases which have been under observation for some months.

This point has been recorded by several other observers. It, as well as the direct connection between enlarged glands and "sleeping sickness," has long been known to the natives of at least the North-Western Coast of Africa, where excision of cervical glands is freely practised as a preventive of "sleeping sickness."

It is interesting to note that enlarged glands were present in many of the supposed cases of "sleeping sickness," whose blood and cerebro-spinal fluid were examined for trypanosomes with negative results in the Lower Congo and Gambia (two cases). Some of these patients have since died of "sleeping sickness."

To determine whether glandular enlargements occurred generally among native populations unaffected by trypanosomiasis, journeys were made into districts where "sleeping sickness" was entirely or almost unknown, and natives were examined for enlarged cervical glands. Tables 7* and 8* compare the results obtained in the heavily infected villages with those from uninfected districts. The contrast between the percentages of "+" cases present in each is striking. The difference is still more marked when seven cases, persons

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* See pages 20 and 21.

who had travelled in infected districts or had newly come from infected districts to the towns in which they were found, are subtracted from the "+" column of the table of uninfected localities (No. 8). The corrected figure is then 1.1 per cent. The persons examined during the seven days' journey inland from Lowa (see "Lowa Trip," No. 6, Table 8), and the "fish sellers at Cabinda" (Table 8, No. 8) were the only persons we saw who were undoubtedly free from any immediate outbreak of "sleeping sickness." Amongst these 834 people there were but four imported "+" cases. The person found to be infected had come to the village only three months previously from an infected district.

Basoko, Yakusu and Katanga are villages on the main river. A good deal of traffic passes through each of them. The disease certainly spreads along the river and cases of imported "sleeping sickness" have been reported from each of these places. We think that the large population about these posts are in the greatest danger. The infected case seen at Katanga was said to have been born there and never to have left his village (?).*

At Ponthierville there are as yet no cases among either the riverine or inland tribes. The one "+" case seen at this place had cervical glands just sufficiently large to place him in this class but had no general lymphatic enlargement.

Along the Congo, in the neighbourhood of Lowa,† there are a very few cases of trypanosomiasis. Inland, as noted above, there are absolutely none, and the natives have never heard of "sleeping sickness." Lukando, and Upoto,‡ villages whose names appear in Tables 7 and 8, show once more how riverine tribes may suffer greatly from trypanosomiasis, although almost no cases occur among the adjacent population living only one or two hours inland. In these two instances the difference between the results of palpation of riverside and inland people is most remarkable. These are, of course, only instances of what is observed in many other places along the Congo.

It has several times happened that isolated cases of trypanosomiasis found in inland villages turned out to be either slaves recently come from infected districts or fishermen who frequently went to the main river to pursue their calling. The three "+" cases seen at the villages inland from Lokandu (Table 8) illustrate this point. Two of the men found to be infected had been

* A report received from Dr. Veroni of Stanley Falls since this was written states that "sleeping sickness" has appeared among the natives about this post.

† See "Distribution and Spread of Sleeping Sickness in the Congo Free State," about to appear in the "Journal of Epidemiological Society," and in this volume.

‡ The inland people here moved to the present site of their village in 1902. They came from two days' journey to the North and away from the Congo.

slaves in infected villages, the third made frequent journeys to a heavily-infected district.

From the corrected figures in Table 8 we may conclude, as might be done from the results of the Lowa trip alone, that, as a rule, **enlarged cervical glands, without obvious cause, do not occur in districts from which trypanosomiasis is absent.**

The practical result of these observations is that **every negro with enlarged glands must be considered,** until the contrary is shown, **to be a case of trypanosomiasis.**

The truth of this statement was long ago suspected (2), its importance was realised and the work embodied in this paper was done in order that its certainty might be incontestable.

Results in every way similar to these have been obtained by the Royal Society's Commission on Sleeping Sickness in Uganda (Report No. VI.), and by Capt. Grattan, R.A.M.C., in Sierra Leone (private communication).

Our main reason for wishing to prove this point was to establish a standard which might be used in attempts to stop the spread of human trypanosomiasis.

The Control of Results.

As is shown by tables 1, 2 and 3, we can form an excellent idea of the value of gland puncture in the diagnosis of cases of trypanosomiasis as compared with other clinical methods. But gland puncture is so much the superior of other methods of demonstrating the presence of trypanosomes in early cases, that it will be only by a prolonged examination of evidence from large numbers of cases that it will be possible to accurately determine the exact diagnostic value of it and of the dependent method of gland palpation. We can control methods of examining blood or cerebro-spinal fluid and detect many overlooked cases by the use of gland puncture. A more efficient method does not exist by which gland puncture can be controlled.

It is, for example, only by continued observation that we can learn what proportion of apparently healthy persons with "+—" and "+——" cervical glands, in whom no parasites were found by the puncture of glands from groups other than the cervical, were actually infected at the time of examination, and would later on develop into "+" cases.

We must note that the percentage of "+—" cases is larger in the heavily infected than in the non-infected districts. The value of palpation of cervical glands, on the other hand, can be controlled by each of the methods of demonstrating the presence of trypanosomes. 271 persons with "+--" and

"+ – —" cervical glands were punctured in one or more groups. "Gland puncture" was thus made to control "gland palpation." Eleven cases with enlargements less than the standard of "+" given above, were found to be infected with trypanosomiasis. All were "+—", none "+ — – –", and as it has already been stated all missed being "+" cases by generally but a small margin.

While in the Congo the finger blood of altogether 2,200 apparently healthy persons was examined, in some instances repeatedly, only 70 cases of trypanosomiasis were detected. All save one had enlarged glands. Forty-three apparently healthy persons were lumbar punctured. One infected person (Case 382) was found. This case had *not* enlarged glands. These figures again indicate that most **early cases of trypanosomiasis have enlarged glands and will, therefore, be detected by gland palpation.**

Preventive measures.

Our experience in the Congo taught us that "sleeping sickness" follows the main lines of communication, and we are more than ever satisfied that it is often carried into new districts by the advent of infected persons. The disease is still spreading with terrible rapidity in the Congo basin. Cases probably coming from the West have already been reported from the East of Tanganyika at Udjiji. One or two imported cases have been seen at the South end of this lake at Moliro, and also in the most northerly parts of the Congo Free State at Wadelai, and in the Lado Enclave.

We believe that something can be done to stem the steady and alarming progress of "sleeping sickness" by limiting the peregrinations of the apparently healthy but none the less infected persons, who at present scatter the disease uninterruptedly about Africa.

Of course the futility of attempting anything like a close quarantine in most parts of Africa is quite apparent to us. But we believe that if every official of the Governments in whose territories "sleeping sickness" exists were informed of the simple fact that enlarged glands mean trypanosomiasis, and given authority to prevent suspected persons from entering uninfected districts, much could be done; at all events infected soldiers and labourers would no longer be brought into uninfected districts, and the white man's posts would no longer form new centres of the disease in previously uninfected provinces.

A few examples are given of the manner in which the disease has been introduced into districts previously uninfected. Dozens of instances like those given below might be recorded from the Congo Free State alone. Similar observations have been recorded from Uganda.

"Sleeping sickness" is said not to exist at Yalembe. Labourers have frequently gone from there to work at Mopolengwe, a highly infected locality. Seventy-four persons were examined; 4 had "+" glands, 3 of these cases (2 were infected) as well as 2 cases of "sleeping sickness" seen in the village had been down river as labourers.

At Romee there is no "sleeping sickness" among the natives. Seven persons with "+" glands (5 infected) were found in 177 labourers, the majority of whom had been brought there from infected districts (*e.g.* the neighbourhood of Kasongo).

A batch of 47 labourers was recruited in the neighbourhood of Lusambo and was taken down the Kasai to work in a district where there is not at present much "sleeping sickness." Nine had "+" glands.

The only cases reported from Moliro and the Lake Kivu are from among the soldiers, their families and the imported servants of white men.

In many places where only a few imported cases existed three to five years ago, there is to-day much trypanosomiasis amongst the resident native population (*e.g.* Cabinda, Tshofa, Kasongo).

In Map III. (see page 32) the intensity with which various districts are infected is roughly indicated by the depth of shading. Posts from which imported cases are reported are indicated by a large red dot. Posts at which there is no "sleeping sickness" by a small black dot. The work on gland puncture and palpation incorporated in this paper was commenced in August, 1904, at Coquilhatville and was continued all along the route followed until the Congo was left in August, 1905.

Whenever places off our route have been mentioned our information has been derived from the answers to a circular letter sent out by us to Agents of the Congo Free State and to missionaries in October, 1903. In many cases our information comes from a second list of answers written at a later date.

Some of the main transport lines for both native and European travel are indicated by uninterrupted red lines.

By a glance at the map it is seen that men stationed at, for instance, Uvira, could control the main routes leading to Lake Kivu. The transport along the Itimbiri and Aruwimi rivers to the north-eastern part of the Free State can be watched from Ibembo, Bumba and Basoko, and "sleeping sickness" would thus be prevented from entering these as yet uninfected districts. To clear posts in uninfected districts, of the imported cases already existing in them, every employée of the Free State is to be informed that enlarged cervical glands mean trypanosomiasis, instructed to watch the native personnel under him and ordered to send suspected persons—towards already infected districts—to the nearest doctor in order that his suspicions may be confirmed.

Each European residing or travelling in uninfected districts will be made personally responsible for the presence of persons with enlarged glands amongst his following.

Only a trained man can puncture a gland and actually find the parasites

in a case of trypanosomiasis. Anyone, even an intelligent native clerk, can detect enlarged neck glands and refer the person possessing them to the nearest physician for a fuller examination.

Persons found to be infected will be sent to already infected districts to live, and if they are capable of it, to work. In this connection it must be remembered that trypanosomiasis is an exceedingly chronic disease and uninfected persons may remain in apparent health for years.

The very simplicity of the measures proposed assures their success. They may be summed up as follows:—

(1) The establishment of posts of inspection along the main routes leading to uninfected districts.

(2) The removal of infected persons from posts in uninfected districts to places already infected.

Regulations along these lines are already being instituted in the Congo Free State. We are confident that if they are properly carried out the advance of "sleeping sickness" will be, if not checked, at least greatly retarded.

Treatment.

By "gland puncture," cases of trypanosomes may be recognised at a much earlier period than heretofore, so it is now possible to commence treatment at a very early stage of the disease, and before irreparable pathological changes may be supposed to have occurred. Thomas and Breinl (5) got better results than had been obtained from any other drugs by treating experimental animals infected with trypanosomes by Atoxyl. This product is being tried on a series of both early and advanced cases in the Congo Free State. If good results are to be hoped for the treatment must be constant and thorough.

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TABLE No. 6.

		+*				+ —*				+ — —*			
	Total number palpated.	Total number.	Number punctured.	Number infected.	% of cases punctured infected.	Total Number.	Number punctured.	Number infected.	% of cases punctured infected.	Total number.	Number punctured.	Number infected.	% of cases punctured infected.
August to October, 1904	2820	139	81	42	51·8 %	588	119	0	0 %	178	8	0	0 %
October, 1904 to July, 1905	3538	373	93	83	89·3 %	820	119	11	9·1 %	1120	25	0	0 %
Grand Totals ...	6358	512	174	125	—	1408	238	11	—	1298	33	0	—
Percentage of each type punctured found to be infected		71·8 %				4·6 %				0 %			

This Table gives the total number of apparently healthy persons palpated, and, so far as our notes are complete, indicates the total number of cases of each type found, together with the number of cases punctured and found infected.

The percentage of successful gland punctures is noted for each class.

* For meaning of these signs see page 11.

TABLE No. 7.

	Total palpated.	HEAVILY INFECTED LOCALITIES. " + ": Total Number.	" + ": Number punctured.	" + ": Number infected.	" + – ": Total Number.	" + – ": Number punctured.	" + – ": Number infected.	" + – – ": Total Number.	" + – – ": Number punctured.	" + – – ": Number infected.
1 Upoto Riverine Tribes	33	9	4	4	—	—	—	7	0	—
2 Bumba	426	29	18	9	50	4	0	1	0	—
3 Tubila	136	5	3	2	31	4	0	66	2	0
4 Lokandu Riverine Tribes	96	22	19	18	26	4	2	21	0	[illegible]
5 Ouliya	97	26	0	—	20	0	—	18	0	—
6 Maomedi	100	28	5	5	33	3	0	24	0	—
7 Tshofa	185	73	10	10	33	14	0	50	2	0
8 Cabinda	99	13	6	5	38	14	0	36	2	0
9 Lusambo	197	16	3	3	65	4	0	35	0	—
10 Manghay	34	14	0	0	15	0	0	3	0	—
TOTALS	1403	235	68	56	311	47	2	261	6	—
Percentage present of each class		16·7 %			22·2 %			18·5 %		

TABLE No. 8.

	Total palpated.	Uninfected Localities.								
		"+"‡			"+ −"‡			"+ − −"‡		
		Total Number.	Number punctured.	Number infected.	Total Number.	Number punctured.	Number infected.	Total Number.	Number punctured.	Number infected.
1 Upoto (Inland people)	225	0	– –	–	11	9	0	3	·	—
2 Basoko*	355	13	10	0	—	–	–	–	–	—
3 Yakusu	356	10	3 (3)†	0	79	17	0	—	–	—
4 Katanga	296	4	1	1	42	30	0	63	1	0
5 Ponthierville	124	1	1	0	37	14	0	33	– –	—
6 Lowa trip (11 villages Inland) ...	809	4	1 (1)†	1	135	30	0	316	2	0
7 Lokandu (6 villages Inland)	224	3	3 (3)†	2	38	1	0	46	0	0
8 Fish sellers from Kabenga examined at Cabinda	25	0	–	—	10	0	—	7	0	– –
Totals	2414	35	19	4	352	101	0	468	3	0
Percentage of each type present		1·4 %			14·5 %			19·4 %		

* Examined Sept., 1904. † Imported cases. ‡ See page 11.

THE DISTRIBUTION AND SPREAD OF SLEEPING SICKNESS IN THE CONGO FREE STATE

THE DISTRIBUTION AND SPREAD OF SLEEPING SICKNESS IN THE CONGO FREE STATE WITH SUGGESTIONS ON PROPHYLAXIS*

Being the Fourth Progress Report from the Expedition of the Liverpool School of Tropical Medicine to the Congo, 1903-05

BY THE LATE

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The paper treats of the distribution and spread of "sleeping sickness" in the Congo Free State, and it proposes measures designed to prevent the extension of the disease to districts as yet uninfected. The results here presented are a part of the work done by the Expedition sent from the Liverpool School of Tropical Medicine to the Congo Free State in 1903.

It will be well to commence by specifying the sources from which was obtained the information on which this communication is based; they were as follows:—

1. *Personal observation.*—Only a small part of our facts was obtained by personal observation. Twenty-three months were spent in the Congo, and during that time we travelled some 2,000 miles. The route followed is shown on the accompanying maps. It is noticed that several short journeys of from one to seven days' duration were made off the main line of travel. The conditions obtaining were carefully noted in each locality visited, and residents—missionaries, state officials and natives—were thoroughly questioned. It was only after passing Coquilhatville that gland palpation and puncture were employed and, as will be shown later on, permitted us to form a really accurate idea of the percentage of natives infected with trypanosomes.

2. *Circular letters.*—In October, 1903, the Free State Government sent out for us a circular letter of questions concerning "sleeping sickness" to its officials and to missionaries throughout the Congo. A second series of these letters was sent out early in 1905.

* This paper was read before the Epidemiological Society at London on October 17th, 1905. It is reproduced here, with some additions, by the kind permission of that body.

3. *Medical Report.*—In 1897 Drs. Bourguignon, Cornet, Drypondt, Firket, Lancaster and Meulman presented at Brussels to the "Congres National d'Hygiène et de Climatologie Medicale" a volume in which they reported on the occurrence of disease in the posts established at that time in the territory of the Free State. Their information, like our own, was in part obtained by personal observation and in part from answers to circular letters of questions which they had caused to be sent to the State's agents.

The greatest part of the information embodied in this paper has, therefore, been collected through questioning natives and more or less observant Europeans. As might be expected the answers have not always agreed, and it has occasionally been necessary to ignore particularly improbable statements; but on the whole there has not been any very great divergence of opinion, and the general result as here given was inevitably arrived at after a short study of our notes. There was, indeed, among many hundreds, scarcely half a dozen answers absolutely incompatible with the general conclusions presented in this paper.

For this reason alone, although the many dangers hidden in evidence so collected are known to us, we think that the history of the spread of "sleeping sickness" in the Congo Free State as given below recounts very nearly what has actually taken place.

Distribution.

The present (1905) distribution of "sleeping sickness" in the Congo Free State is shown on Map III.* In this, as in the other maps, areas where "sleeping sickness" is endemic are stippled with red dots. No information was obtained concerning certain unexplored or unsettled districts. These are roughly shown by crossed lines. With these possible exceptions it is believed that practically every locality in the Free State has been noted at which cases of "sleeping sickness" occurred before the middle of 1905.

In many localities the presence of "sleeping sickness" has remained for a time unknown to the resident Europeans, and even to the natives themselves. In others, although the disease is seen to be present, its nature remains unrecognised. Errors from both these causes have undoubtedly occurred in the reports sent to us, and cases of "sleeping sickness" may possibly in reality occur amongst the natives in districts off our line of travel marked as uninfected. As has already been said, much of the information incorporated in this paper has been derived from questioning many hundreds of persons. It is therefore believed that no very grave error can exist.

* See page 32.

Predisposing Causes.

As is usual, peoples living along the banks of large bodies of water have suffered the most heavily. Tribes living even a short distance inland from the rivers have often remained comparatively immune, although the neighbouring riverine peoples were much infected.

Upoto and Lokandu illustrate this point. At these places about 25 per cent. of the river people are infected. At Upoto 225 persons from two hours further inland, who had been settled for two years in villages only a mile and a half from the river, were examined. Not one was infected. At Lokandu 224 inhabitants of villages situated from 10 to 15 miles from the river were examined, 3 were found to be infected. All three had been exposed to infection by living for some time in districts where " sleeping sickness " was epidemic.

As is suggested by these instances, the disease seems to spread but slowly from an infective centre.

Isolated cases of "sleeping sickness" occurred among the Bobangi, riverside people, at Tschumbiri before the arrival of Europeans in the Congo. In 1893 these people suffered very severely from the disease; but it was only in 1901 that the first cases were noticed amongst the Bateke, who live only a short two miles inland. *Glossina palpalis* was seen to be present at Tschumbiri and Lokandu.

We have been told that " sleeping sickness " was caused by eating manioc, through lack of salt, smoking hemp, drinking palm wine, or by excessive coitus, and that it might be contracted through using drinking utensils employed by infected persons or through coitus with them. All of these statements seem mistaken. In an infected population all classes, male and female, adults and children, are equally susceptible. (By gland palpation and puncture trypanosomes were found in a baby less than nine months old.)

Famine and hard times are said to induce " sleeping sickness."

Lukolela and the country of the Batetelas are cited as examples. The Batetelas had suffered depredations from the Arabs. They were disturbed by the war between whites and Arabs in '92-94, ravaged by revolted soldiers in '95-96, and oppressed by a native chief until a few years ago. Food became scarce, and at present " sleeping sickness," previously unknown among them, is spreading very rapidly in their country. Occasional cases of " sleeping sickness " had occurred at Lukolela before 1880. After a small war with the Government in 1896 the crops were lost. Food became scanty and of poor quality and cases of " sleeping sickness " were much more frequently seen amongst the resident natives.

From the analogy of trypanosome-caused diseases in animals it does not seem improbable that unfavourable conditions might decide a declaration of the disease in persons already infected. Apart from this, and excepting always the susceptibility of fishing and river-side peoples, no peculiarity or tribal custom has been observed to predispose natives to " sleeping sickness." Villages placed on high ground and at some distance from even a small stream of water have, however, occasionally be found to be heavily infected.

For instance, Palabala (near Matadi) is situated at the top of a high hill and is at least 10 minutes' walk from a stream, yet it has suffered severely from sleeping sickness. The conditions

are much the same at Cabinda, a large compact town, yet 13 per cent. of its population is infected. At Miambwé the native village is much spread out over a cultivated, upland plain in groups of two to five houses. Each group contains a single family of perhaps five to a dozen persons. When we passed at the commencement of the dry season there was almost no water in the water-course distant half-a-mile from the nearest of the houses. There was no scrub or bush in the neighbourhood, and even in the wet season no marsh would exist near any of the houses. Nevertheless about 7 per cent. of the population was infected. A similar observation was made at other villages in this locality.

Glossina palpalis was found practically everywhere along our route. At many places in the grass country, as at Miambwé, they were extremely rare and an hour's search at midday in the most probable places along wooded streams more than once resulted in a failure to see a single tse-tse of any species.

It may be that the flies become more numerous in the rainy season; otherwise, in spite of the great chronicity of human trypanosomiasis, it would seem impossible for them in these localities to be altogether responsible for the large numbers of persons actually infected with trypanosomes.

It is certain that the annual percentages of deaths from "sleeping sickness" in an infected population may vary greatly. In partial explanation it is often plausibly stated that declared cases are most numerous during inclement seasons. It may be so, but there are also probably variations in mortality among an infected population quite independent of seasonal influences or famine or the number of *Glossinæ*. In some localities the intensity of the disease seems to be lessening.

In 1886 cases of "sleeping sickness" were very numerous in the Lower Congo. Many of the missionaries living there, some of them residents of 25 years' standing, state that the percentage of deaths from "sleeping sickness" is much less now than then. (In some cases their opinion is verified by the mission books in which the dates and causes of deaths of *church members only* are entered.) Nowhere in the Congo, outside of the district of the Cataracts on the lower river did we hear from natives or Europeans any trustworthy history of a former increase in the number of cases of "sleeping sickness" similar to the present exacerbation. Only at Lukolela did the natives have a vague tradition of a former epidemic.

Spread.

In order to obtain a graphic representation of the spread of "sleeping sickness" in the Congo, maps have been prepared which show the approximate distribution of the disease at three points of time—1884, 1897, 1905. The same maps roughly indicate the main lines of communication employed during the years immediately preceding each date.

1884, Map I.

In 1884, Europeans had no influence in the Congo basin. The Free State was not yet established. The whole of the Eastern province was controlled by Zanzibaris who, through their allies and lieutenants, ruled Central Africa and exacted tribute from Avakubi to Cabinda. The slaves and ivory for which they exploited the country were taken out by the waterways and over well-

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defined trade routes. Practically speaking, they never got further down the Congo or Aruwimi than Basoko, where the Free State placed a military camp in 1888 to stop their advance. Nor did they establish themselves far to the West of the Congo. They had, however, a powerful ally in this district in Gongo Lutete, a native chief living at Gandu. Through him they constantly obtained slaves from as far West as Lusambo. In addition Arab caravans were sent from Kasongo to Lusambo to purchase slaves and native-made ironware. It is to be noticed that none of the Arab routes touched districts infected at that time with "sleeping sickness."

The natives themselves had well recognised trade routes over which merchandise passed. On some routes the goods were passed on from tribe to tribe. On others, caravans carried produce or slaves to market many days away.

For instance salt from Nyangwé and cloth and powder from the Portuguese west coast found their way to Pania Mutombo and Luluabourg. These goods were bartered from hand to hand, and those who bought and sold never went long distances to find markets. There was at Tschimbango an important local exchange to which came people from Pania Mutombo, Luebo, Lusambo and Luluabourg—rarely anyone from further away.

The roads along which went tribe-to-tribe traffic are indicated by dotted red lines. Routes where traders travelled long distances by canoe or caravan are marked by unbroken lines.

Perhaps the longest journeys were made by the tribes living along the Congo between Tshumbiri and Nouvelle Anvers. These people regularly took slaves from the Ubangi and from above the equator to Leopoldville, where they were sold to native traders from the neighbourhood of Lutete (Wathen) to be resold later in Portuguese territory at San Salvador. Another long native transport route is from Lake Kasali to Cabinda (a journey of 20 days' walk). To this day caravans of 100 to 200 persons come monthly to Cabinda with dried fish. They formerly brought, as well, salt from Kiambi.

Traders from the Upper Congo frequently went as far as Wathen with their slaves. "Sleeping sickness" has existed for probably more than fifty years at Wathen, and it seems probable that this constant stream of travellers may well have carried "sleeping sickness" back with them to their homes as high up the river as midway between Nouvelle Anvers and Upoto.

There was a brisk village-to-village commerce among the natives along the upper river in salt, fish, cam-wood powder, slaves and iron tools. Such a means of communication easily explains a short additional extension of the disease to Bumba, the highest point at which "sleeping sickness" was known before the arrival of the Europeans. This statement implies that "sleeping sickness" was unknown above Bumba in 1884. In making it we rely upon the evidence of Europeans who have lived for many years in the locality, and upon the reports given by natives. No district in which "sleeping sickness" has once existed is

known to have ever become entirely free from the disease. Cases may become more rare but they do occur, and the natives always know and have a name for the disease. In many places along the Upper Congo between Basoko and Kasongo the disease is, or was until recently, quite unknown, and the natives either coin a new word to describe it or use the Kisuaheli name.

Some tribes acted as professional middlemen and carriers and controlled the commerce from the interior of the Coast. For example, the Bakiokos and other tribes from Portuguese territory regularly traversed the southern and western part of the Free State, and even went as far as Pania Mutombo where they exchanged cloth and powder for slaves. They had no regular posts or agents who collected slaves for them; but as they went inland trustworthy men were left in friendly villages with goods and orders to buy slaves. As the caravan returned westward each of these headmen was picked up with his little gang of slaves. Because their wants were supplied by these middlemen none of Pania's people ever traded far to the West and no long distance trading was done down the Kasai. We believe that it is for these reasons alone that "sleeping sickness" remained quite unknown to the natives about Lusambo until 1896. There was no constant, intimate and direct communication with infected districts.

The main routes used by the traders from Portuguese territory are marked with a "P."

Near Lake Leopold II. is a village marked with a query. Its chief asserts that "sleeping sickness" existed there before Europeans appeared in the country. It is probable that he is wrong since white men saw no cases in the district when they first entered it, nor were cases reported from that locality until much later. If he is right "sleeping sickness" had possibly a much wider distribution in 1884 than we suspect.

1897, Map II.

In 1885 the Free State was founded. Steamers were put on the river and transport by the great waterways commenced to be rapid and easy. In 1888 the first step was taken towards suppressing the slave trade. The campaign to limit the power of the Arab raiders was opened by the establishment at Basoko and at Lusambo (1889) of fortified camps. At the same time expeditions were sent in all directions to explore and open up the country, so it was not until 1892 that the war really commenced which, in 1894 at Nyangwé, resulted in the complete destruction of the Arab power. These large movements involved a journeying of men previously unknown in the Congo. Natives came from so far as the neighbourhood of Bandundu to carry loads over the caravan route

from Matadi to Leopoldville. Soldiers and labourers employed on the Upper River often came from the infected lower Congo.

The main movement against the Arabs went overland from Lusambo to Kasongo. Through Lusambo passed, until the mutiny of 1895-96, the whole of the transport from the West to the Great Lakes and to the South of the Free State. In this way large numbers of persons from infected districts entered these hitherto uninfected regions.

In 1896 the first recognised case of "sleeping sickness" occurred at Pania Mutombo. The date is given with great unanimity by natives of all the surrounding tribes. From this centre the disease has rapidly spread in all directions, but, in particular, along the much-used caravan route between Lusambo and Kasongo. Until 1901, save for an interruption in 1895-96 caused by a mutiny of soldiers, this road was in constant use. It was the line of communication from the Lower Congo with all the Eastern part of the Free State. Along it there was much transport of supplies, produce, and comparatively large numbers of soldiers. The route was frequently used by natives who, for example, carried taxes to Kasongo from places as far off as Cabinda.

About 1894 labourers were first engaged from about Pania Mutombo to work in the Lower Congo. When their term of engagement was ended they returned, with many time expired soldiers, to settle rich men in their old homes about Lusambo. Their presence doubtless added many new centres of infection. We have been told that they frequently died, shortly after their return, from "sleeping sickness."

The extension of "sleeping sickness" has been more rapid to the East of Lusambo towards Kasongo than to the South towards Cabinda. This is to be explained by the fact that the country to the East of Lusambo has been more influenced by the changes of recent years. The transport through this region was the larger; it had been twice fought over; more natives have been engaged to work in other parts of the Free State from this region than from the districts to the South of Cabinda.

The waterways supplied an excellent means of transport which permitted the Free State to pursue its policy of reaching the heads of the rivers in order to effectively occupy the whole of the Congo Basin. One result of this policy is well seen at the present day in the distribution of "sleeping sickness" along the Kasai River. The natives on either bank of its middle reaches had but little to do with strangers, and even to-day, save at Manghay where there is a very old-established plantation to which labourers are said to have been brought from all parts of the Congo, there is little or no "sleeping sickness" along the

middle part of the river. At its mouth and at the limit of navigation case numerous.

During the mutiny of 1895-96 the caravan route from Lusambo to Kas was closed and transport to the Lake region went by way of Stanley Fall the way up the Congo to Kasongo. This is the route used at present fo the traffic from the West to the country lying to the East of the Congo, N of 5° and South of 1°S. The extension of "sleeping sickness" which follc the subsequent increase of transport along this old highway of the Arabs is evident on comparing the maps showing the distribution of the disease in and 1905.

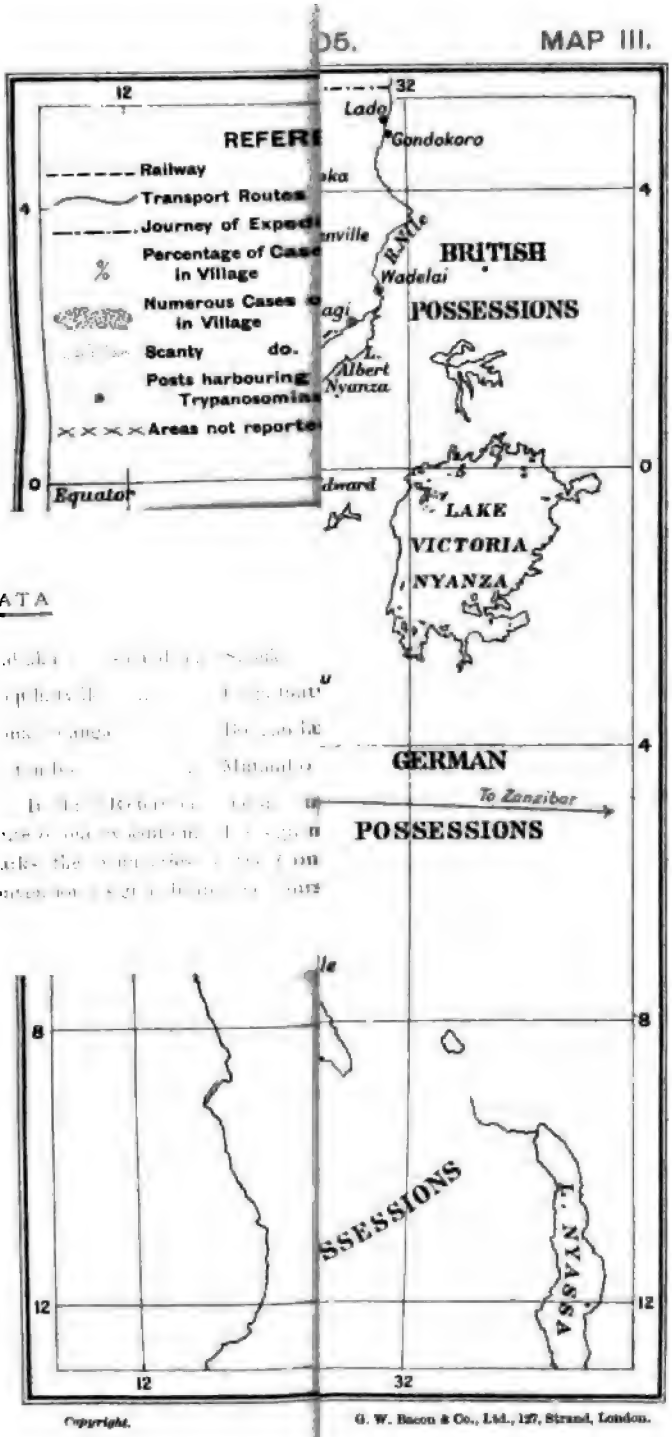
The present severe epidemic commenced at Kasongo at about 1900-1 since then "sleeping sickness" has spread steadily down the Congo as as up. From Kasongo the disease extended with terrible severity along much-travelled transport routes which lead to Lake Tanganyika and the dist about Lake Kivu. It is still spreading rapidly. At the commencement of 19 the disease was confined fairly well to the natives living on either side of t caravan route. Occasional imported cases alone were reported from posts the South on the shores of Tanganyika and inland. Letters received since th return of the Expedition to Europe say that cases are commencing to be see among the natives resident in this region.

Map IV. gives the dates at which the present epidemic of "sleepin sickness" is usually accepted to have made its appearance in the localitie indicated.

It is interesting to note that the villages (Kirunda and Kama) most infected along the lo part of the river between Stanleyville and Kasongo are inhabited by Arabised natives who do great deal of trading. At this moment they journey particularly between Stanleyville and Manie the latter a *heavily infected district*. There can be no doubt that this constant native traffic h contributed largely to the extension of "sleeping sickness" along the Congo to the north Kasongo. Natives, as in the villages opposite Ponthierville, who do no travelling have remain uninfected. It is not without interest to note that one of the first cases of "sleeping sickness" see at Kaya was a Zanzibarite who had settled there 10 years previously and had come into the Cong by way of Uganda.

Even if all these dates are granted to be correct, and if it is assumed that "sleeping sickness" did follow the entrance of persons from the infected Lower Congo into the Kasai and Maniema, it may still be protested that these events do not stand to one another in the relation of effect and cause. It is, of course, impossible to actually prove that they do; but that it is probable is evident from a consideration of the reports given of the directions in which "sleeping sickness" has spread, and by enumerating the numbers of places in which "sleeping sickness" is said to have appeared amongst residents after the deaths of imported cases.

05. MAP III.



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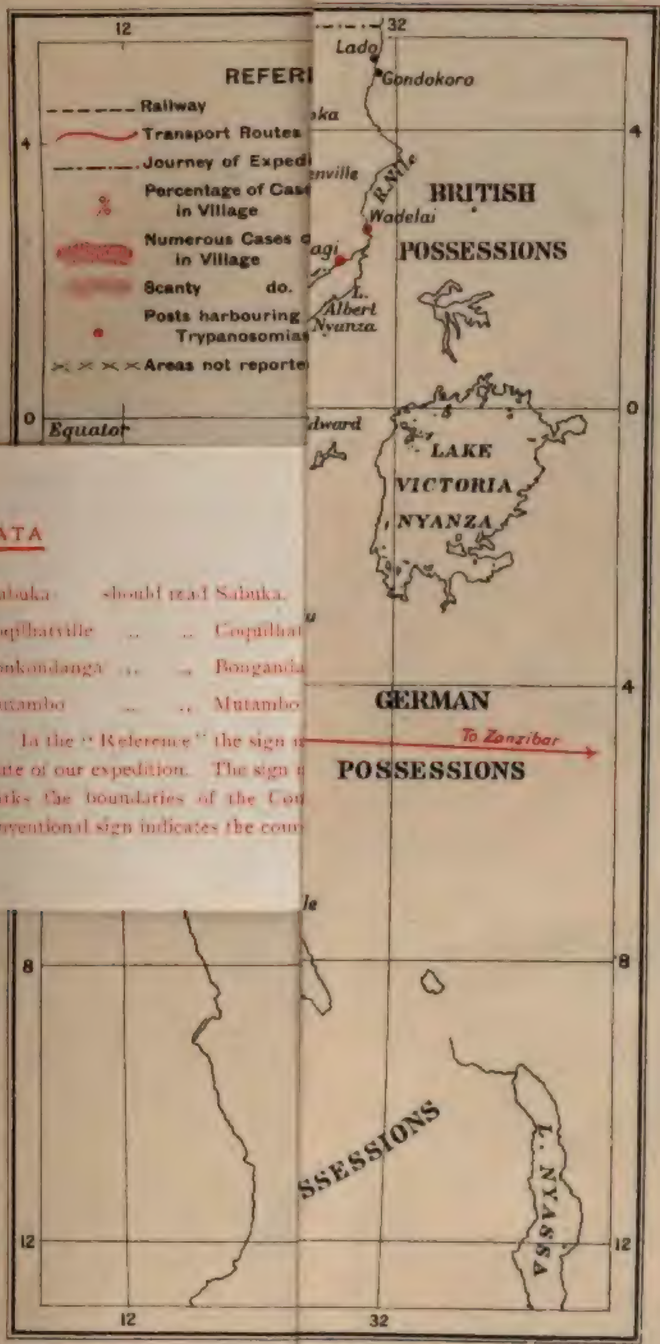

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Mutambo ... ... Mutambo

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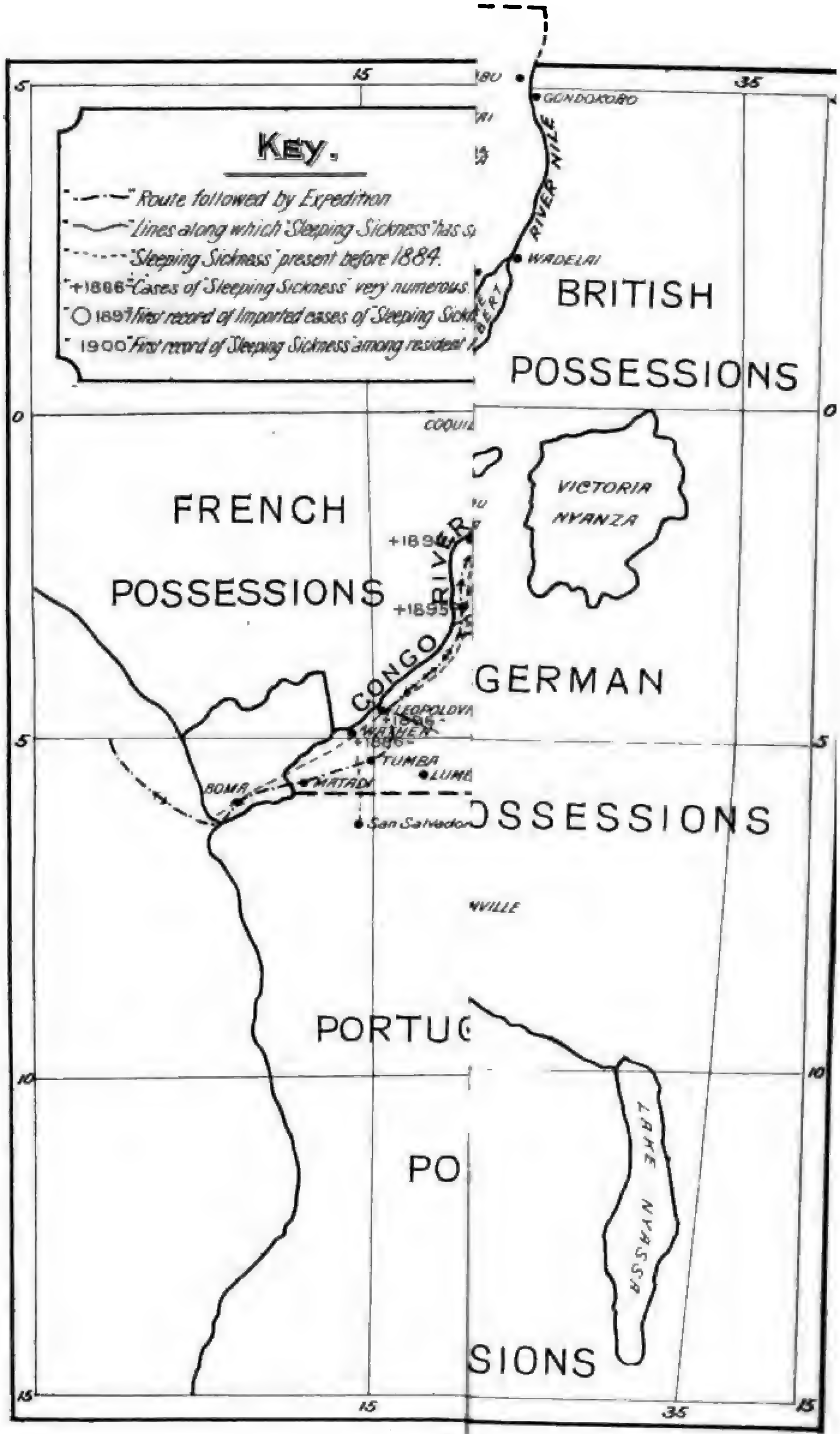

Key.
Route followed by Expedition
Lines along which "Sleeping Sickness" has s
"Sleeping Sickness" present before 1884.
+1886 Cases of "Sleeping Sickness" very numerous.
1897 First record of Imported cases of "Sleeping Sick
1900 First record of "Sleeping Sickness" among resident
GONDOKORO
RIVER NILE
WADELAI
BRITISH
POSSESSIONS
VICTORIA
NYANZA
FRENCH
POSSESSIONS
CONGO
RIVER
GERMAN
LEOPOLDVI
TUMBA
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MATADI
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15
35
0
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The dates of the appearance of the first cases and frequently the names of the patients are unhesitatingly given in many places in the heavily infected area between Lokandu, Lusambo, Cabinda, Albertville and Baraka. At Cabinda, Miambwé and Tshofa "sleeping sickness" is always said to have commenced at and to have come from Pania Mutombo. At Lokandu it came from Nyangwé. The first case recognised in 1903 at Baraka was a labourer returned from Leopoldville. All the cases detected by gland palpation in 1905 at Yalembé, where "sleeping sickness" was thought not to exist, had been to Mopelengue as labourers. The first cases reported at Ilé, Luebo, Kutu, Mutombo Mukolo, Kabambare, Buli and Basoko, as well as at the posts marked by red dots or circles in as yet uninfected districts, were all imported.

As is shown by Maps I. and II., "sleeping sickness" has existed for many years along the Congo and Ubangi rivers.

Map I. indicates how frequently the disease is said to have existed "before the arrival of the whites." At Lukolela and Bamamia we received information equivalent to an assertion that the disease had been present in these localities for over 50 years.

It, nevertheless, seems certain that there has been a great increase in morbidity along these rivers within the past fifteen years. Europeans living at the following places at the period indicated have said, in evident error, that "sleeping sickness" was then unknown among the neighbouring natives; at Mopolengue in 1890, Bolengi in 1899, and at Nouvelle Anvers in 1895. Had the disease existed at these periods in anything like its present intensity it would seem impossible for them to have missed seeing cases. In addition, at many places both natives and Europeans join in saying that there has been in recent years a great increase in the number of cases. In many instances the approximate date is given, and it is often asserted that the increase has gradually travelled up river.

From the information we have received it is, however, impossible to decide if the epidemic raging on the upper river from 1890 onwards is an extension of the epidemic which existed on the Lower Congo in the eighties.

Gland Puncture.

An enlargement of the superficial lymph glands has long been recognised to occur in "sleeping sickness." Before the identity of "sleeping sickness" and trypanosomiasis was known, enlarged glands were described in several cases of human trypanosomiasis. Their presence was at first thought to be probably accidental and not characteristic; but the study of large numbers of patients in different parts of Africa soon showed that glandular enlargements were a constant feature of early cases of trypanosomiasis.

In 1904 Greig and Gray found that trypanosomes were usually present in the juice drawn by a hypodermic syringe from such glands. The line of work thus indicated was followed up, and in the Congo the following facts were demonstrated. Practically the same results have been obtained in Uganda by the Commission of the Royal Society and by Captain Grattan, R.A.M.C., in Sierra Leone (private letter):—

(1) It was found that trypanosomes could practically always be found in the glands of cases of trypanosomiasis. Our percentage of successful examinations in a consecutive series of 250 patients was 97.2 per cent. The method seems particularly good in detecting early cases in whom all clinical signs are wanting. We had 98.5 per cent. of successful examinations in a series of 130 consecutive early cases; *i.e.*, patients in whom there were no obvious clinical signs of their disease.

(2) (*a*) It was suspected that many of the apparently healthy natives possessing enlarged glands, which had been thought to be not abnormal in negroes, might really be early cases of trypanosomiasis. To decide this point natives were examined all along our route and we have concluded that every native who lives in an infected district and has a general glandular enlargement, without apparent cause, is almost certainly a case of trypanosomiasis, even though he seems entirely healthy.

Persons with apparent causes for their glandular enlargements as Tuberculosis, syphilis, skin and scalp disease have not been considered in compiling any of the figures in this paper referring to gland puncture. Such persons were however not infrequently infected (8 in 26 examined).

(*b*) A comparative study of the glands in 300 of our patients showed that the general glandular enlargement of cases of trypanosomiasis might be conveniently estimated by palpation of the posterior cervical triangles; 89.3 per cent. of the persons chosen because of their enlarged cervical glands from 3,538 apparently healthy natives, palpated between October, 1904, and July, 1905, were demonstrated to be cases of trypanosomiasis.

(3) To determine whether cervical glandular enlargements, without apparent cause, occurred in natives inhabiting districts uninfected by trypanosomiasis, 2,414 natives among whom "sleeping sickness" was said not to occur were palpated. Only 1.4 per cent. were found to have enlarged cervical glands.

Some of the villages examined, as Basoko and Yakusu, were only just outside the districts recognised as infected, and it was only in 834 natives from Lowa and Lake Kasali that we met persons from districts certainly uninfected. Three amongst these people had enlarged glands. All three were newcomers and had previously lived in infected localities.

The contrast between this figure and that from 1,405 natives from heavily infected districts, of whom 16.7 per cent. had much enlarged glands, is very striking. The logical conclusion resulting from these premises is apparent.

We have in cervical gland palpation a wonderfully simple and very accurate method of detecting, especially, those cases of trypanosomiasis in whom marked clinical signs are wanting.

It is believed that the first part of this paper proves that much of the extension of sleeping sickness in the Congo basin during recent years may be directly attributed to the disease being *carried* into uninfected districts by the migration of just such persons.

Prevention of Sleeping Sickness.

The lack of a rapid and efficient method of diagnosis has heretofore made it impossible to attempt any quarantine against "sleeping sickness." In cervical gland palpation we have a simple test which, even in the absence of a physician, may be accurately applied by an intelligent person. We believe that measures based on this fact may be usefully employed to safeguard uninfected districts against invasion by trypanosomiasis.

The gist of the measures which have been advised and are already being initiated in the Congo Free State are:—

(1) The establishment of posts of inspection along the main roads to prevent the entrance of infected persons into uninfected districts, and

(2) The removal of infected persons from posts in uninfected districts to places already infected.

The application of these measures will be obtained by informing every agent of the State of the significance of enlarged cervical glands. Each chief of a post will be directed to examine his staff and to send suspected persons towards infected regions to the nearest doctor, where, if it is necessary for diagnosis, the patient will be watched. Each white man will be made to understand the importance of preventing persons with enlarged glands from proceeding towards uninfected districts, and will be given authority to prevent their progress.

A reference to the maps will show how effectually the main routes of communication between infected and uninfected districts can be controlled in the Congo. The North-Eastern corner of the Free State is usually reached from the West by the Itimbiri and Aruwimi rivers. Physicians placed at, perhaps, Bumba and Ibembo, Basoko and Yambuya with full powers, could very effectually control all ordinary traffic. To the East the roads to the South of Lake Albert used now by Arabs for trading from Uganda into the Haut Ituri district, and formerly as a slave route, must also be watched.

Practically all communication from the Lower Congo to the district about

Lake Kivu passes by Uvira. A medical officer placed there could easily watch the road. Almost everything coming from the West destined for the South of the Free State passes through Cabinda. These examples will be sufficient to show that the first of our proposals can be applied in practice in so far as the ordinary traffic is concerned.

Some opposition will be necessarily encountered in enforcing these regulations. It is particularly certain that there will be much objection to the second. Trypanosomiasis is an exceedingly chronic disease. Infected persons may remain in apparent health and be perfectly capable of steady work for several years. Indeed, it is not at all certain that recoveries do not occur, and both employer and employed will resent any interference with their arrangements on the score of a few enlarged glands. Both must appreciate that this proposal does not mean the loss of a labourer, but merely his transference to an already infected district, where his presence will only add to and not create a centre of infection.

The futility of attempting to suddenly institute anything like an absolute quarantine in the network of paths in Africa, is, of course, quite apparent to us; but though the application of the scheme outlined may not immediately stop the spread of "sleeping sickness," we are confident that a strict supervision of travellers and of the soldiers and labourers about the Government's posts will do much to check its progress in the Congo Free State. At all events, it will no longer be possible for Europeans to introduce large numbers of infected labourers and soldiers into uninfected districts as has often been done in the past.

The following are a few additional instances in which large numbers of infected persons were brought into uninfected regions. Deaths occurred from "sleeping sickness" during the years from '89-92 among the Lower Congo soldiers stationed at Basoko. About 2,000 labourers, many of them coming from Maniema, the district about Kasongo, are at present working on the railroad which is being built from Stanley Falls to Ponthierville. Several recognised cases of "sleeping sickness" have occurred among them. The disease has remained unrecognised in other cases and they have been dismissed as "unfit for work." We found three such persons in the uninfected villages along the river between the Falls and Ponthierville. In a detachment of fifty labourers engaged near Lusambo to work as head men in a previously little-infected concession on the Kwango almost 20 per cent. were infected.

It may be once more pointed out that at each of the posts marked on these maps by large red dots imported cases of sleeping sickness have died in, at that time, non-infected districts.

A mission school was founded at Berghe Saint Marie in 1890; large numbers of children were collected there from many widespread districts. In 1895 "sleeping sickness" commenced, it was said to have reached the school from the neighbouring Bobangi people. The disease steadily increased until in 1898 there was a mortality from this cause of 39.9 per cent. among the 461 children then at the mission (1). It was decided to abandon the mission, and in 1900 the children still living were sent in all directions to other missions. Almost all subsequently died of "sleeping sickness." Many persons believe that much of the spread of the disease is directly due to this unfortunate occurrence. Though it is now apparent that this step was ill-advised, it seems probable that not as much harm followed as is usually imagined; since "sleeping sickness" already existed in the localities to which the main detachment of the unfortunate children were sent.

Such incidents will be prevented by the adoption of the scheme outlined. It will be more difficult to control the movements of individuals, but if Africans, white and black, learn to appreciate the importance of keeping infected persons out of uninfected districts, much can be done. Natives will soon learn that enlarged glands mean "sleeping sickness." They know it already in North-western Africa. The idea of quarantine is not altogether strange to them, since in many places in the Congo the natives of their own accord isolate their sick in huts built far away from the main village.

We have been told that one tribe in Maniema objected to natives from infected districts entering their territory lest "sleeping sickness" be introduced with them.

If the proposed measures are carried out with the usual thoroughness of the Congo Free State administration, we believe that much good will inevitably be done. The application of these measures will involve much expense and the alteration of much in the existing methods of transport and administration. Before attempting to enforce them executives must inquire exactly what result may be expected from them if they are efficiently applied and, if the result hoped for is attained, whether it will constitute an adequate recompense for the outlay it has necessitated. All that can be expected with certainty from a rigid quarantine such as is proposed, is that the advance of "sleeping sickness" towards districts at present uninfected will be checked, not stopped.

The known distribution of human trypanosomiasis in Africa is much less than the known distribution of the variety of *Glossina* which transmit the disease. We must suppose from our present knowledge that in the ordinary course of events trypanosomiasis would eventually spread into every district where the fly exists. Our proposal expresses a belief that the hundreds of thousands of natives living in such regions, at present uninfected, may be protected for a lengthy period from the danger threatening them. (It must be remembered that while "sleeping sickness" may be quickly *carried* from place to place, it *spreads* but slowly from an infected centre.)

Whether the effort to realise this benefit is worth while can best be appreciated by considering what has been the results of the recent epidemics of the disease in Uganda and the Congo Free State. It is quite impossible to state accurately the number of persons who have died from trypanosomiasis in the territories of these governments. Complete censuses do not exist. In much infected localities deaths are often ascribed to "sleeping sickness" which in reality are due to other diseases. (On the other hand, the disease is often present for some time before its presence is recognised.) It is impossible to keep track of tribes or smaller collections of natives who have left their old

homes to avoid the disease. It is, however, certain that populous districts have become almost deserted within a few years and that a large proportion of the deaths were certainly due to " sleeping sickness." The figures usually given for the numbers of deaths from trypanosomiasis during the past ten years in Uganda and the Congo are so colossal that we shrink from repeating them. Because of the following observation we, nevertheless, believe that they approximate the truth. It was found that from 30 per cent. to 50 per cent. of the population was infected in many of the villages along the route we followed between Lokandu and Cabinda. It is generally accepted that only a very small percentage of persons infected with trypanosomes can be expected to " recover." Therefore, at least *a third of the people inhabiting these districts will probably die of trypanosomiasis.*

It seems advisable that the utmost should be done to protect uninfected districts from a like fate.

Our conclusions are:—

(1) The enormous spread and great increase of " sleeping sickness " in the Congo basin during recent years has been due, in a great measure, to the increase in travel following the opening of the country.

(2) Cases of trypanosomiasis, though apparently healthy may be detected by their enlarged glands.

(3) Good results may be expected from the serious application of quarantine measures dependent for their efficiency upon cervical gland palpation.

REFERENCE.

1. Van Campenhaut and Dryepondt. Rapport du laboratoire medical de Leopoldville, 1899-1900, Brussels, 1901.

ON A NEW DERMANYSSID ACARID

Pneumonyssus duttoni, n. sp.

ON
A NEW DERMANYSSID ACARID
FOUND LIVING IN THE LUNGS OF MONKEYS
(CERCOPITHECUS SCHMITDI)
FROM THE UPPER CONGO

Sixth Interim Report from the Expedition to the Congo, 1903-04-05, of the Liverpool School of Tropical Medicine

BY

ROBERT NEWSTEAD, A.L.S., ETC.,
(LECTURER ON ECONOMIC ENTOMOLOGY AND PARASITOLOGY)

AND

JOHN L. TODD, B.A., M.D. McGILL

(WITH ONE PLATE)

While the Expedition was at Lusambo, Dr. Poledro, Medicin de 1ère classe de l'Etat Independant du Congo, kindly offered his assistance. In doing an autopsy on an experimental monkey he found in its trachea the acarid described in this paper. It has subsequently been frequently seen.

Thirteen monkeys of the " Funny Type " (*Cercopithecus schmitdi*), including both young and adults of both sexes have been examined. Eleven of them harboured these parasites. These animals were collected between Kasongo and Lusambo. Six specimens of *Cercopithecus ?campbelli* from the same localities have been examined, but none were infested by these parasites. Neither has it been found at the autopsies of five monkeys (*Cercopithecus callithrix*) from Sierra Leone.

The adult acarids, both fully and partially matured, were found in the trachea and bronchi from the larynx down to the second and fourth or even to the fifth branchings of the bronchi. The larvæ were found, but infrequently, and only in the smaller bronchi. Eggs have not been yet seen.

Frequently the presence of this parasite seems to cause no symptoms; occasionally there is a slight bronchitis which may be ascribed to it.

It is interesting to note that females only, no males, were seen.

Pneumonyssus duttoni, n. sp.

Adult female (figs. 2, 3) opaque white; very elongate, cylindrical, slightly attenuated posteriorly; division of cephalothorax and abdominal areas marked by a broad and rather deep constriction.

Dorsal Scutum (fig. 3, *ds*) of cephalothoracic area almost covers the anterior region, posteriorly it gradually merges into the cuticle so that the line of demarcation is not traceable.

Palpi (fig. 4, *p*) approximate, of three joints, length equal, but the basal segment is nearly as broad again as the apical segment, the latter with two or three rather long stiff hairs. Mandibles (fig. 4, *m*) very elongate and styliform, the apex slightly curved.

Anal orifice (fig. 10) placed near the posterior end of the ventner, and surrounded by a rather large and extremely finely punctate plate bearing three minute spines. Spiracles or stigmata (fig. 3, *st*) in two pairs, the anterior pair placed between legs III. and IV., the posterior pair near the first fourth from the anal extremity.

Legs (fig. 6) well developed and with many fine spinose hairs; legs I. to III. equal in length; IV. the longest, and about one-third the length of the entire body; leg I. of six segments, the remaining legs of seven segments; tarsal claws of leg I. (fig. 7) retractile, simple, curved apically and somewhat bluntly pointed, bases separated; claws to legs II. and III. (fig. 8) lateral, strongly curved and widely divergent, with the bases almost touching; tarsal claws to leg IV. (fig. 9) similar to those on leg I. but somewhat shorter and more strongly curved, they are also more widely separated from the tarsal segment.

Length of old adult female 0.50—1 mm.

Habitat in the bronchial passages of a monkey (*Cercopithecus schmidti*) in the Kasongo district of the Congo, Africa.

Hexapod larva elongate, narrowed in front. Abdominal extremity with several very long hairs. Palpi long, tapering towards the apex, of ?4 segments, all bearing a number of rather long hairs; apical segment with one very long hair almost equalling the length of the palpi; and one or two minute hairs. Legs long and stout, with many long hairs, some of which are about one-third the length of the leg; tarsi pedunculate; ungues or claws apparently equal.

This species is closely allied to *Pneumonyssus simicola*,* but differs in the possession of an additional pair of stigmata and a large dorsal scutum or shield; it is also of a much more elongated form. The presence of a dorsal scutum

* Found in the lungs of a Javanese monkey.

points to its relationship with *Halarachne*,† but the latter has cheliform mandibles and five jointed palpi.

The styliform mandibles, evidently fitted for piercing, lie within a very delicate mandibular sheath, which latter is very difficult to trace (no sections made). The dorsal scutum is also difficult to trace, in fact it is invisible in freshly prepared specimens, but after immersion in Farrants' medium for a few hours this organ becomes clearly visible and is seen to be strongly and regularly striate on the anterior margin.

The course of the tracheal tubes was clearly indicated in a specimen which was placed for a few minutes in glycerine ; the trachea going from the posterior stigmata were then seen to traverse the ventner, while those proceeding from the anterior stigmata traversed the dorsal region chiefly.

We have dedicated this species to our late colleague, Dr. J. Everett Dutton.

† Living *in* seals.

EXPLANATION OF THE PLATE.

Fig. 1.—Group of four females. Two old adults and two young ditto. The latter have their legs and capitulum completely buried in the mucous lining of the trachea. Note that legs i.-iii are also buried, while leg iv. remains on the surface of the mucousa almost at right angles to the body.

Fig. 2.—Adult female dorsal. As seen before the integument was cleared.

Fig. 3.—The same after clearing the integument; st. stigmata; ds. dorsal scutum; a o. Anal orifice.

Fig. 4.—Capitulum; p. palpi: m. mandible; m p. mandibular plate or sheath. x 600.

Fig. 5.—Mandible. x circa 1200.

Fig. 6.—Leg iii.; c. o. coxa: tro. trochanter: fem. two jointed femur: pat. patella: tib. tibia tar. tarsus ung. ungues. x 160.

Fig. 7.—Tarsus of leg i. x 600.

Fig. 8.—Tarsus of leg iii. x 600.

Fig. 9.—Tarsus of leg iv. x 600.

Fig. 10.—Anal orifice. x 600.

ON ANOTHER NEW DERMANYSSID ACARID

Pneumonyssus griffithi, n. sp.

ON ANOTHER NEW DERMANYSSID ACARID

Pneumonyssus griffithi, n. sp.

ON ANOTHER NEW DERMANYSSID ACARID PARASITIC IN THE LUNGS OF THE RHESUS MONKEY *(MACACUS RHESUS)*

BY

ROBERT NEWSTEAD, A.L.S., ETC.

(WITH ONE PLATE)

Seeing the great amount of interest attached to the discovery of these internal parasites it has been thought a fitting opportunity to describe this additional new species.

The Dermanyssidæ to which this and the preceding species belongs, includes the two sub-families (according to Banks' recent classification) Dermanyssinæ and Halarachnina.

These, although differing much in general appearance, are closely allied by structure to the Gamasidæ, but their parasitic habits have apparently been taken as the best character for their separation.

These families include six genera, and taking all the characters together, this and the species described in the preceding paper fit best into the genus *Pneumonyssus*. They differ, however, in one important character, namely, the presence of a dorsal scutum, which character agrees with the genus ***Halarachne***, found inhabiting the bronchial passages of seals; but this character is, I find, very difficult indeed to trace, and may, in all probability, have been hitherto overlooked.

I must here acknowledge my indebtedness to Professor Rubert Boyce for placing the whole of the material in my hands, and also for his able report on the pathological condition of the infected lungs. To Dr. C. A. Stanley Griffiths, the discoverer of this interesting parasite, I am also indebted for the history and the account of his microscopical examination. His report is given at the end of the diagnosis.

Pneumonyssus griffithi, n. sp.

Adult female (fig. 1) creamy-white, opaque; elongate, in width a little less than half the length of the body. Palpi (fig. 6) short, of four sub-equal segments; apical segment shortest, and bears a minute slender spine at the apex. Mandibles stiliform; scutum (fig. 2) with three pairs of short stout hairs; and there are also four bilateral groups of pores of which the third is lineal and divergent. Legs (fig. 3, leg IV.) normal, each of the segments with a few fine short hairs; claws (figs. 8, 8*a*) equal, strongly curved; pulvillus extending considerably beyond the claws. Stigmata (fig. 5) between legs III. and IV.; peritreme anteriorly elongated.

Length 0.75 mm.

Larva (fig. 7) hexapod; short ovate. Legs clothed with very long hairs; second and third pairs directed forwards; anterior pair geniculate; tarsi (figs. 8, 8a) very slender; claws equal; pulvillus divided into lateral radiating rod-like divisions.

This species may be distinguished from *Pneumonyssus simicola* by the presence of a dorsal scutum; the much shorter palpi, and the presence of a pulvillus to the tarsi.

This acarid was first found in a series of six adult Indian rhesus monkeys (*Macacus rhesus*), belonging to the Royal Commission on Tuberculosis, which were killed on account of having been in contact with a monkey suffering from spontaneous tuberculosis.

"The lungs of all these animals showed small cavities which did not in any way resemble tuberculous lesions, and guinea-pigs inoculated from them failed to develop tuberculosis.

"Smear preparations made from the contents, however, revealed the presence, in some considerable number, of acid-fast bacilli, these bacilli were demonstrated by Dr. Steegmann who had found them on a previous occasion in a similar case. Further examination of the cavities showed that each contained several small white bodies which, on microscopical examination, proved to be parasites.

"The cavities varied in diameter from two to about five mm., and were chiefly situated just under the pleura, but were also met with in the depth of the lung; on the surface they appeared as slightly raised greyish yellow areas, some with a distinctly lobular outline; on section they communicated with small bronchi and had thin fibrous walls lined internally with a soft silvery or greyish white *débris* in which the parasites were usually found lying; sometimes

the whole cavity was filled with this *débris*, whilst in others there was very little, the walls in the latter case being smooth and showing the openings of small bronchi.

"Microscopical examination of the *débris* showed it to consist of desquamated epithelial cells and leucocytes and in some instances, when suitably stained, to contain acid-fast bacilli.

"In several adult monkeys parasites were found in large thin-walled emphysematous bullæ at the apices and around the margins of the upper lobes.

"The parasitic cysts have been met with in the great majority of the rhesus monkeys examined, and in some were very numerous.

"They were most numerous, and were practically never absent, in the adults of the species, the lungs of the younger animals either having been quite free from them or having contained only one or two."—(Griffith *in lit.* January 15th, 1906.)

EXPLANATION OF THE PLATE

Fig. 1.—Adult female (ventral). x 60.

Fig. 2.—Dorsal scutum of adult female. x 100.

Fig. 3.—Leg IV. of adult female. x 250.

Figs. 4, 4a.—Tarsi of adult female. x 600.

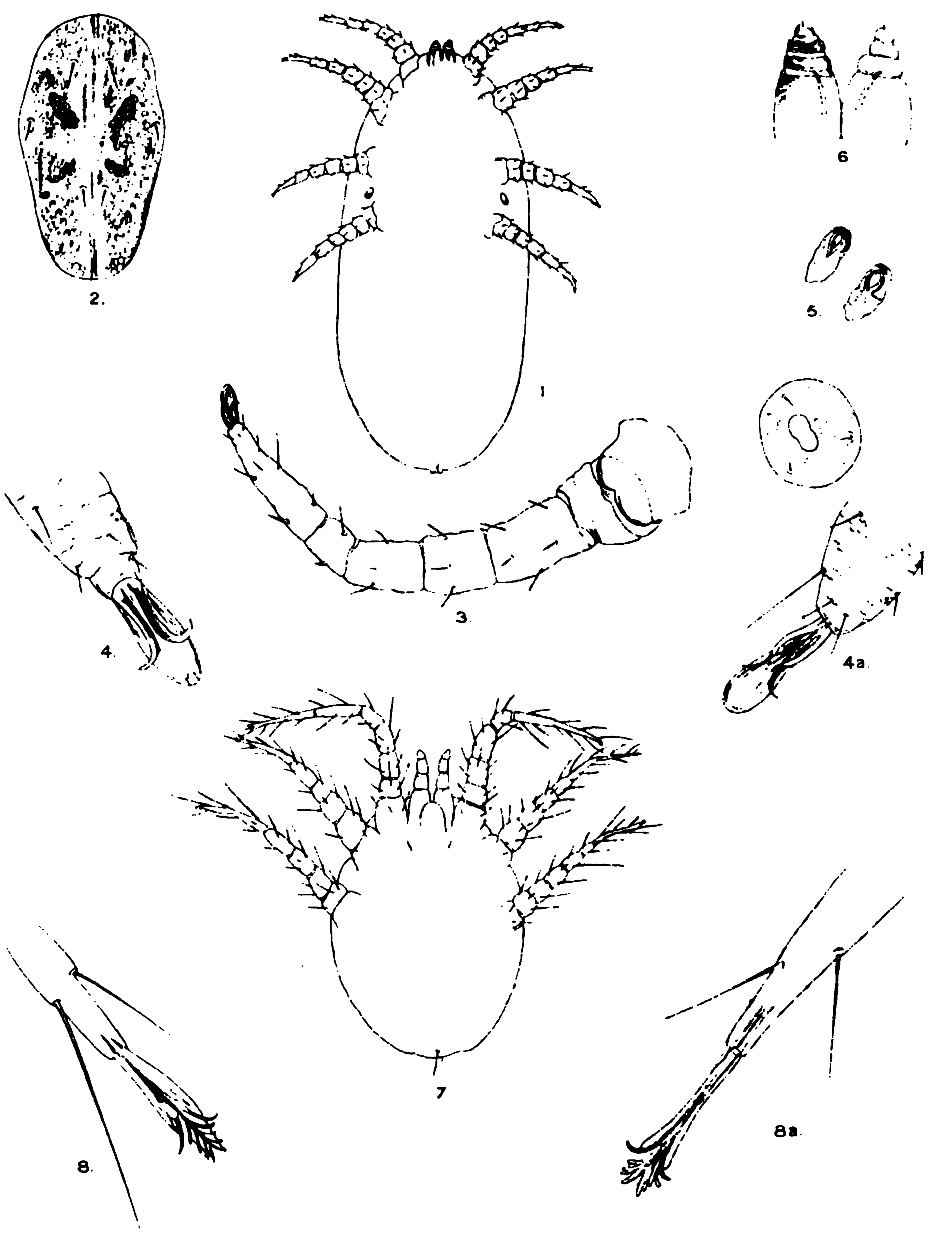
Fig. 5. Stigmata of adult female. x 600.

Fig. 6.—Palpi of adult female. x 600.

Fig. 7.—Larva. x 120.

Figs. 8, 8a.—Tarsi of the larva. x 600.

The figure without a reference number is that of the anal orifice of the adult female.



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PNEUMONYSSUS GRIFFITHI, n. sp.

THE ANATOMY OF THE PROBOSCIS OF BITING FLIES

THE ANATOMY OF THE PROBOSCIS OF BITING FLIES

BY

J. W. W. STEPHENS, M.D. CANTAB.

AND

R. NEWSTEAD, A.L.S., F.E.S., &c.

I. GLOSSINA (Tsetse-flies).

We desire in the first place to offer our sincere thanks to Dr. J. L. Todd for his kindness in placing at our disposal a large part of the material used by us.*

The species examined by us in this investigation was almost exclusively *Glossina palpalis*, R.D., and the description always refers to the female of that species, unless otherwise stated.

Without claiming any special merit for our own work, we think anyone who has examined the proboscis of a tsetse-fly and then refers to what has been written on the subject will soon be convinced that the descriptions are wanting in completeness, that many structures are left undescribed, and that the descriptions are not easy to follow. This, in a measure, has apparently been due to the want of sufficient material.

We trust that in this paper we may be able to fill many, if not all, of these lacunæ. In one respect, however, we must admit that our descriptions will lack the completeness we desired, for the tissues, muscular and nervous, have been so imperfectly preserved that we are only partially able to describe them. With regard, therefore, to the actual mechanism of the parts of the proboscis we must remain in some doubt, but we hope eventually to make this clear when we have compared the proboscis of *Glossina* with that of other biting flies.

With regard, however, to the chitinous frame work, we believe our research to be fairly complete.

METHODS.

(1) By simple dissections it is quite easy to shew many structures hitherto undescribed. (2) By cutting serial sections in paraffin or in celloidin-paraffin the relationship of parts is shewn in a manner impossible by the first method. (3) For softening the chitin, Eau-de-Javelle and potash were used. Perhaps the best results were got by boiling for some hours in a 10 per cent. solution of

* This investigation has been included in this memoir as much of the material used by us was collected by Dr. Todd in the Congo and the subject is a cognate one to that of trypanosomiasis and Tsetse flies.

potash. By this method the chitin was softened without being dissolved, as happens with Eau-de-Javelle if it acts too long. Softened and unsoftened probosces were imbedded, sometimes in paraffin alone, sometimes in celloidin-paraffin (Ide's method); on the whole no preference for any one method declared itself.

TERMINOLOGY.

So far as possible we shall use terms already in use, but so many structures exist of which we can only guess the function that it seems only possible at present to give them descriptive names. We must defer any more accurate terminology until we have compared these parts with similar structures in other probosces.

For convenience sake we may divide the proboscis into four areas:—

(1) The tip or area of the labella (fig. 2, *a-b*).
(2) An intermediate area, for the most part " membranous " (fig. 2, *b-f*).
(3) The proboscis proper (fig. 1, *e*).
(4) The bulb (fig. 1, *h*).

The tip of the proboscis is a most complex and formidable apparatus. We may picture it to ourselves as a bilaterally symmetrical structure consisting of two walls on each side, the external wall one either side being separated from the internal by soft tissues. The two external walls meet ventrally and are, in fact, continuous, in the form of the rounded ventral surface, with the exception of an apical (longitudinal) V-shaped cleft. The internal walls meet ventrally, but are not continuous with one another. In the angle between them lies the hypopharynx, though this does not extend to the tip.

Dorsally and externally the internal walls are jointed to the external by a thin membrane, and at the point where this meets the external wall there are a number of fine teeth (fig. 2, *d*) which interlock with the corresponding teeth on the other side so that normally the labella are closed or capable of being closed dorsally. These teeth extend practically to the extreme tip. How far they extend in the other direction we shall describe later. While then for the most part we have between the outer and inner wall soft structures (muscles, &c.), as we approach the tip we find a number of longitudinal rods, four on each side, arising from the outer surface of the inner plate. Arising nearer the tip there are other longitudinal antenniform spines. These are situated on the outer surface of the internal plate. There are two of these on each side. These, like the longitudinal rods, extend as far as the tip. If we consider further the structure of the internal plate on either side, we see that while at some distance from the tip it simply shews signs of being

divided into an upper, middle and lower segment, yet nearer the tip *each* of these segments becomes specialised in a wonderful manner, so that on each segment we encounter (1) rows of minute bars or rods, "the rasps" (fig. 7, *a*); (2) two pairs of large conical teeth (fig. 7, *b*); (3) beyond these a number of flat scales which radiate in a fan-shaped manner to the extreme tip, "the fans" (fig. 7, *c*). On the external plate on either side we have forming the actual edge: (*a*) a number of incisions about 20 in number, and confined chiefly to the dorsal half of the edge (fig. 4, *c*); (*b*) three very minute spines (fig. 4, *b*) arising from this incised edge externally: these are, as a rule, difficult of demonstration, but there is no doubt as to their existence; (*c*) eight large thorns (fig. 4, *a*) symmetrically placed on each external plate, four near the tip, two further back and two opposite the very dark thick portion of the outer plates (labella); (*d*) three small stalked conical spines arising from the inner surface of the external plate, corresponding in position to the three segments of the internal plate (fig. 5).

We have said that ventrally the external plates were united almost to the tip, but at the tip they are deficient by the space of a V-shaped incision. This incision is not, strictly speaking, V-shaped, but is truncated, because the actual angle is occupied by a number of ventral scales, thus completing the ventral surface at this point. Beyond this point the ventral surfaces are not united.

Dorsally, as we have seen, the labella are (potentially) open for their whole length; in the normal condition they are, however, closed by the interlocking of the dorsal-lateral-internal rows of teeth.

Very conspicuous, on examination of the tip with a low magnification, is the dark chitinous area a little behind the tip. As we shall see on considering sections, this appearance is due to the thick dark external wall. Behind this area we come to the almost membranous intermediate area where the ventral chitinous border is for a space interrupted. Leaving aside for the present some very peculiar spines in the lateral walls of this area, we find next projecting into this area a broad fork of chitin, which probably plays an important part in the mechanism of the tip. This fork consists of a handle and two prongs or curved portions (fig. 3, *e*). The handle is a continuation of the most ventral portion of the chitin of the labium, and where the handle ceases this chitin of the ventral border also ceases. The handle, however, now expands outwards, forwards and upwards, being convex outwards so as to form a prong on either side of the wall of the intermediate area (fig. 3, *e*). Its attachments and connection with the proximal portion of the dark thickened chitinous area of the labella we shall describe later. This fork is capable of changing its position, for in one specimen (fig. 8) we have the handle lying as far forward as the dark chitinous area, so

that the attachment of the handle is now in front of the points of the fork which are directed backwards. How this change in position is brought about we shall discuss later.

In this position we see that the rasps of the labella have been completely protruded and everted (fig. 8, *o*). How necessary the examination of fresh specimens is to a complete understanding of the mechanism is shewn by the fact that of all the specimens examined by us only one shewed this condition.

Nearer the base than the fork we reach the proboscis proper, which presents the same characters throughout its length until the bulb is reached. The proboscis, *e.g.*, in its middle consists of three portions (fig. 21): (1) the ventral labium, which is hollowed out dorsally in the centre into a groove in which runs the hypopharynx; (2) dorsally the labrum, which anastomoses with the labium by a series of teeth on either side, and (3) the hypopharynx.

On its ventral side the labium is beset externally with two parallel rows of spines, or rather double spines, of a peculiar character, which extend as far as the bulb (fig. 2, *i*). Also on the external surface a little distance behind the handle of the fork laterally on either side exist three spine-bearing tubules (fig. 2, *g*).

The labrum carries near its tip on its outer surface a pair of hairs set on a pairs of stalks or comparatively long tubercules (fig. 28, *b*). Similar stalked hairs are again met with as the labrum approaches the bulb. Here they are first arranged in a double row, the stalks in one row alternating with those on the other, till finally on the bulb they become exceedingly numerous and are approximately arranged in triangular areas (fig. 29, *a-b*). Behind these stalked hairs finally exist a series of rows of minute hairs.

The labium widens out eventually into the bulb and the labrum also becomes fused with the bulb. In fact, the hypopharynx also in a sense becomes merged in the bulb, for it eventually loses its existence as a separate tube in the labial groove, and becomes a thick-walled tube lying in the muscles of the bulb.

The labrum closes in the dorsal surface of the labium, locking with it by means of its teeth; but it has also a connection of a very delicate nature, as we shall see, with the hypopharynx, for on either side the labrum, beyond the portion provided with teeth, is continued as a delicate filament (membrane), which is attached to the lateral wings of the hypopharynx.

Thus the labrum and hypopharynx form a closed tube, while the labrum and labium, though closed by their interlocking teeth, are capable of being opened. We may now consider these parts in detail.

THE LABELLA.

The labella may be divided into three portions, (*a*) the part posterior to the dark area; (*b*) the dark area, and (*c*) the portion anterior to this.

In the anterior portion (fig. 4, *a*) on the external lateral plate there are eight large formidable looking spines directed backwards, which are symmetrical with those on the opposite side. The position of these spines is a little variable. Generally two occur opposite the dark area, two nearer the tip, and four almost at the margin. Two of these are generally nearer the tip than the other two. In the figure the position of the two spines furthest from the tip is not that usually seen. Nearer the tip than these large spines are three minute spines (fig. 4*b*), about equidistant. They are situate practically at the margin among a number of incisions which actually constitute the free edge of the external plate (fig. 4, *c*). The number of these incisions is about fifteen to twenty. Besides these there are no structures on the lateral external surface of the labella near the tip. If now we focus down through the external plate we find, in successful preparations, three spine-bearing tubules situate on the inner side of the external plate (fig. 5, *a*). These, then, are the only structures on the external lateral plate of the labella in the region beyond the dark area.

If we examine the internal plate we find, however, a complex and formidable apparatus. On its external side (fig. 6, *a*) we find four long, jointed, hollow, chitinous rods with a short basal and long distal portion, the latter of which is also constricted at its base. Two of these rods are central, and one on either side lateral, corresponding in position to the three rasps which form the inner surface of the plate. These rods appear to arise from the external surface of the plate not by a joint but by fusing gradually with the substance of the plate. They appear to open by a minute slit-like aperture at their apex. On the inner surface of the internal plate we find a complicated structure consisting of "rasps," teeth, and "fan-like expansions" covered with scale-like spines which become almost filamentous at the extreme margin. The rasps (fig. 7, *a*) consist of a dorsal, middle and ventral segment, separated from one another by an incurvature of the plate, so that in cross section (fig. 12) they are seen to be really convex plates with the convexity turned inwards towards the lumen of the tube. Each rasp consists of about 10 rows, each row being composed of about 30 minute bars or rods, set roughly parallel to the long axis of the proboscis. The number of rows in each rasp in the specimen figured (fig. 7) was ten, eight and eleven. (In *Gl. fusca* they are more numerous.) At the point where the rasps cease apically, occur three pairs of conical teeth, one pair on each rasp. Beyond these occur three other pairs of still larger teeth

(fig. 7, *b*). Both sets of teeth have their apices directed forwards. Betwe the base of these large teeth are seen commencing a series of spine-like scal (fig. 7, *c*). At the base there are only two scales between each pair of teet but apically these expand into a fan-shaped series of scales almost filamento in character (fig. 7, *c*).

If now we examine the relation of the external and internal plate to o another as shown, for instance, in figs. 10, 11, 12, we find (1) that the apices the labella are not united at this level; (2) that the chitinous rods lie in t space between the two plates. This space is also filled with tissues. As v proceed basally these take the form of definite muscle bundles united ventrall In fig. 10 we see the large teeth cut through and the spiny scales between the In fig. 11, a little lower down, we find portions of the large teeth shewing, ar the commencement of the rasps. In fig. 12 we find the rasps cut across about their middle. In this section also we have figured the dorsal teeth s on a membrane between the internal and external plates. Fig. 13 is at a lev where the two sides of the labella are united ventrally, and at this point (*a*) v have on the external surface a number of scale-like spines cut across, depict in fig. 3, *j*, filling the apex of the V-shaped incision in the ventral wall of t extreme tip. Fig. 15 is a section through the dark area of the labella, ar probably represents the parts in almost their natural position. We find t dorsal teeth (*a*) almost interlocking, and the inner plates (*b*) folded over o another. At this level the inner plates show evident signs of being divided into three sclerites or segments, an apical slender plate, a median, and a sho thick ventral plate which is almost in apposition with that of the opposite sid It is in this groove that the hypopharynx first appears in section when c through in the region of the dark area. The dorsal teeth which exte practically to the tip and are set on little areas, in groups of four or five on ea area, we believe, serve the purpose of an interlocking apparatus as shewn fig. 15, but on comparing this section with fig. 16 it will be seen that they ha become more ventral in position, and, in fact, they dip down lower than represented in fig. 16, and at the same time the teeth gradually disappear that in the membranous region of the labella we have a region of the probosc where the dorsal surface is not closed by teeth. It is at a slightly lower lev (fig. 17) that teeth first appear on the inner surface of the inner plates whi interlock with those on the external surface of the labrum. Passing towar the bulb we next reach the membranous area of the labella in which tw striking structures exist, viz., on each side a small organ armed with a trip spine (fig. 3, *c*), and, secondly, on each side the forked chitinous plate which is extension of the ventral portion of the labium into this area (fig. 3, *c*).

The spine-bearing organ is a little tumulus on the lateral ventral wall of the membranous portion of the labella. The tumulus internally consists of three rather thick-walled chitinous tubes, which extend some little way into the substance of the wall. On the summit of the outer end of each of these tubules is set a minute spine. These organs are shewn in section in fig. 16.

The next important structure which no doubt plays an important part in the mechanism of the proboscis is the forked chitinous plate, which is really an extension of the ventral portion of the labium extending into the membranous region where the forks are articulated with projections of the chitinous portion of the labella (fig. 3, *k*) extending backwards from the dark area. Seen in profile the handle of this chitinous fork bends first ventrally, then again dorsally, becoming narrower where it joins the two forks. Each fork then may be considered as embracing the side of the membranous wall at this level. The direction of the fork is upwards (dorsally), outwards and forwards (apically). At its apex it is conical in shape and is overlapped by, *i.e.*, is internal to, an expansion backwards of the chitin of the dark area (fig. 8, *k*). This thin chitinous expansion of the dark area is folded on itself, the outer fold now becoming the external wall of the dark area at this level. There are three other chitinous sclerites which call for mention in this area. Some little distance below the fork occurs on either side of the labium a definite club-shaped thickening of the wall (fig. 3, *n*). From this can be traced, in the direction of the fork, a membranous line more or less clearly defined, but which has, about half way between these thickened clubs and the fork, a minute chitinous plate (fig. 3, *m*), and thirdly over the apex of the fork near its articulation with the dark area a thicker curved chitinous plate (fig. 3, *l*).

We have already stated that the position of the fork may be reversed, viz., the point of attachment of the handle may be nearest the apex and of the proboscis, and the tips of the forks directed outwards and backwards. This difference in position is partly, if not entirely, due to the fact that the *external* plates have been pulled back towards the bulb. In this position the apices of the fork are well covered by the posterior arms of the dark area, and the triple spines likewise now lie *interior* to the posterior portion of the dark area. The whole of this area constitutes a kind of membranous sac permitting of alteration of shape and also of bending of the proboscis as a whole at this point.

As we reach the labium proper we have further a group of three spine-bearing tubules (fig. 2, *g*), situate just anterior to the thickened chitinous club-shaped sclerites mentioned above.

THE LABIUM.

We have already, in the general description of the armament of the proboscis, referred to the peculiar spines which exist in a bilateral group along its whole ventral surface (fig. 2, *i*). These, like many other structures, have not, as far as we are aware, been hitherto described. They consist of two parts, (1) an extremely long and fine curved spine fitting into the outer margin of what is apparently a groove. They have their points directed towards the bulb (fig. 2, *ii*), and (2) at the base of these spines and apparently closely connected with them a little disc bearing a fine hair (fig. 2, *ii*). As already stated, they extend as far as the bulb. The only other external feature of the labium itself are the polygonal markings (fig. 2, *h*) on the external surface of its lateral arms, through which, in transparent specimens mounted entire, can be seen the teeth (fig. 2, *hh*) which lie on the inner surface of these arms. For understanding the structure of the labium recourse must further be made to sections. If a series of sections be followed from the labella downward we see that there is a continuity between the inner plates of the labella and the dorsal portion of the labium. In fact, the two inner plates seen, for instance, in fig. 16, gradually alter their shape and become united ventrally in fig. 19, taking on in fig. 20 the shape which produces the groove in which the hypopharynx lies. In fig. 21 it is seen that the labium consists of two parts, a dorsal grooved portion with lateral arms bearing teeth, and a ventral portion which is articulated to the former by a more or less membranous joint, probably permitting of some lateral movement here. So that of these portions the *dorsal* is represented by the inner plates of the labella, whereas the outer plates of the labella are new structures and represent really the labella proper, while the *ventral* portion of the labium is represented near the tip by the bifurcated plate of the intermediate area which terminates at this point and does not extend into the labella proper.

We have, apparently, a somewhat similar arrangement in the Culicidæ where the dorsal portion of the labium is continued on to the extreme tip, while the ventral portion stops short and articulates with the labella. The groove in which the hypopharynx lies is at first deeper than broad, but widens considerably later till these two measurements are about equal. On the inner surface of the lateral margin of the labium are a number of teeth on each side, five to eight in number according to the level. They serve the purpose of interlocking with those on the labrum and so forming a closed tube. The soft structures in the labium are disposed in the following way, though varying in detail at different levels (fig. 21): –

(1) A pair of muscles attached to the thick chitinous walls on either side of the groove (*a*).

(2) A pair of muscles attached along the lateral walls (*b*).

(3) A single ventral band (*c*), and

(4) Two central tendinous bands occupying the median area (*d*), and extending from the bulb as far as the intermediate area (triple spines), where they can no longer be followed.

THE LABRUM.

This forms the dorsal covering of the proboscis (fig. 27). Apically it extends as far forwards or a little beyond the labial region proper, or where the tip of the proboscis takes a ventral curve. Its structure is best understood by a study of sections. Commencing as an almost flat apical piece it soon expands laterally, the lateral margins curving inwards and ventralwards so as to form a concavity, which fits into the arms of the labium (fig. 21). On either side its walls are hollow (*h*), and beyond these hollows the arms are externally beset with teeth on either side (*g*). The number of these teeth varies according to the level of the section, but in many levels they are more numerous than the teeth on the labium with which they interlock. Basally the labrum becomes fused with the bulb (fig. 24) forming here a continuous tube, which constitutes eventually the pharynx. On its external surface it bears a number of hair-bearing papillæ (figs. 28 and 29, *b*). Near the tip these are two in number; they are very constant in position, and the hairs are long and fine (fig. 28, *b*). These papillæ are not again encountered until the labrum approaches the bulb. Here they occur as two rows on either side, the papillæ in one row alternating with those in the other, in the region of the bulb (fig. 29, *b*) they become far more numerous, and are disposed all over the dorsal surface in a fairly regular pattern. Still nearer the base the papillæ are replaced by simple hairs (fig. 24, *a*).

THE HYPOPHARYNX.

The hypopharynx is, at its commencement in the dark area of the labella, just below the base of the rasps, a delicate chitinous tube surrounded by a membranous wrapping. This outer tube is not spherical, but projects on either side as a small loop (fig. 21), to which is attached the delicate membranous prolongation of the lateral walls of the labrum, so that the labrum is, in fact, in direct continuity with the hypopharynx in such a way as to form a second tube lying upon (dorsally) the hypopharynx (fig. 21, *f*). Where the labrum ceases this tube also ceases to exist, but the hypopharynx is still enveloped by its outer sheath as far as it extends, and, indeed, the sheath in the labellar regions appears

to be loose and voluminous, if not actually attached to the inner plate of the labella. The hypopharynx lies in the lateral groove, and as we reach the bulb this groove resembles strikingly that of a rowlock in appearance (fig. 23). This groove eventually flattens out and the hypopharynx is then simply opposed to the flat dorsal surface of the bulb. The loops of the investing membrane become here more extensive and eventually fuse with the lateral muscular tissue of the bulb as the hypopharynx passes from the dorsal surface to the centre of the bulb. By this time the hypopharynx has acquired a thick muscular wall and has, lying dorsally, the tube which now constitutes the pharynx (fig. 25).

In one male specimen examined by us these lateral appendages of the hypopharynx differed in appearance from what we have just described. The lateral appendages instead of being hollow loops were solid expansions, which, in the same way as the loops, became eventually fused with the bulb. In the lumen of the tube was a mass of secretion (?) having spherical clear areas in it.

MECHANISM OF THE PROBOSCIS.

We have pointed out that the inner plate of the region of the labella is a direct continuation of the dorsal portion of the labium. The chitinous fork of the intermediate area is also a prolongation of the ventral portion of the labium. Further, the labium ventrally becomes fused with the chitin of the bulb. Consequently it seems to us impossible that there can be any independent motion in the long axis of the proboscis of these parts. For the same reason also, owing to its fusion with the bulb, no movement of the labrum is possible. If this be so it follows that the only portion of the proboscis capable of free longitudinal motion are the outer walls of the tip or true labella. That this explanation is the true one is, we consider, proved by making measurements from a fixed point in the labium, *e.g.*, the first ventral pair of spines. If we measure now in two cases (1) as in fig. 8, with the rasps exposed, and (2) in the normal position (fig. 3), we find that the distance from the fixed point to the post edge of the dark area is greater in the normal position than in the extended position .
This means that the external plate has been *pulled down* towards the bulb. Further, we believe the labellar region is capable of being expanded laterally as shown in fig. 16. This motion is presumably affected by the muscles which extend from side to side, passing across the base of the internal plates.

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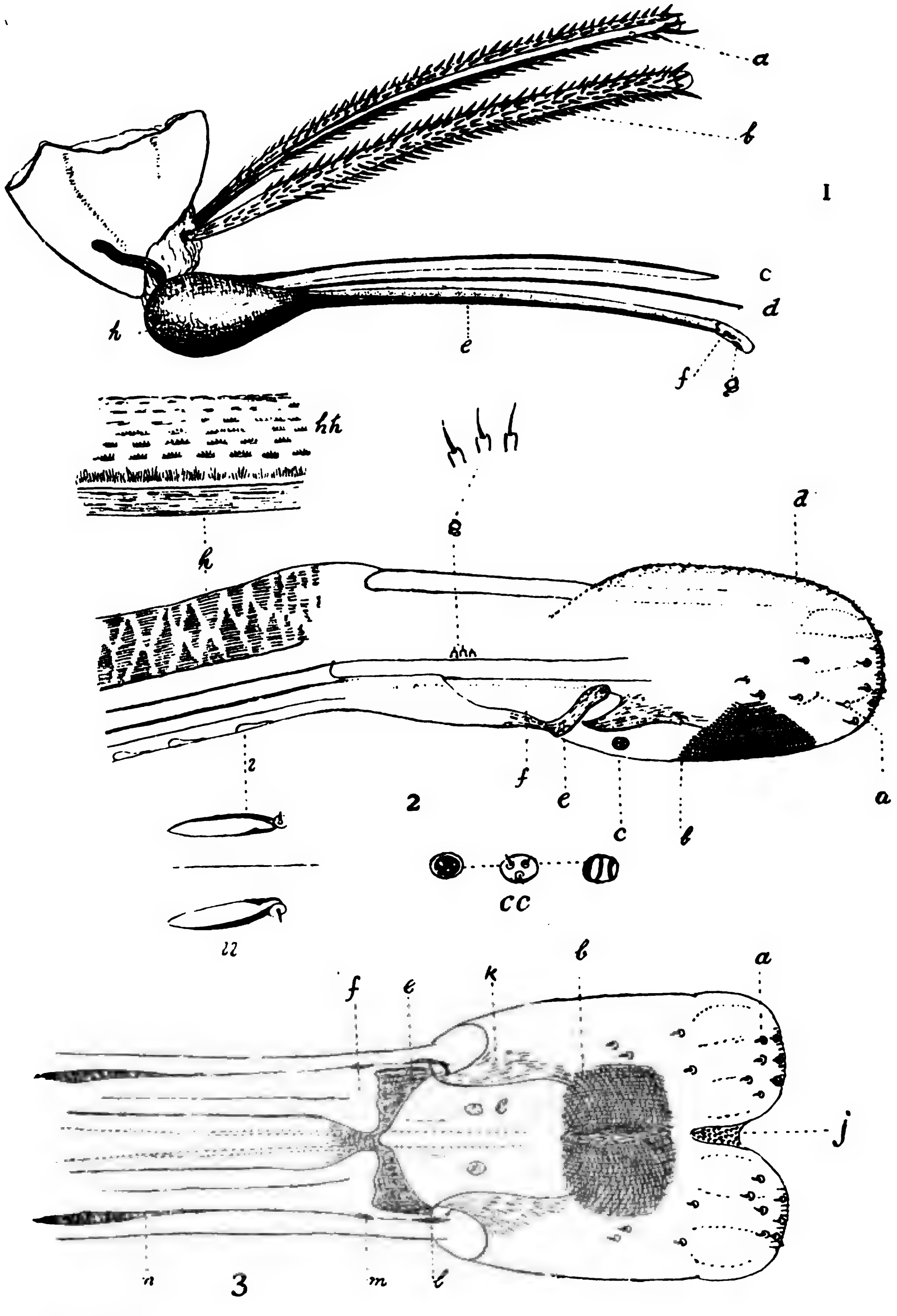
EXPLANATION OF FIGS. 1 to 4.

Fig. 1.—General view of proboscis seen in profile. × 25.
- (*a* and *b*) Palpi.
- (*c*) Labrum
- (*d*) Hypopharynx
- (*e*) Labium proper.
- (*f*) Bifurcated plate or fork.
- (*g*) Dark ventral chitinous area of labella.
- (*h*) The bulb.

Fig. 2.—General view of tip of proboscis in profile. × 250 approximately.
- (*a*) Spines on external wall.
- (*b*) The dark ventral chitinous area.
- (*c*) Tubular tumulus bearing three minute spines.
- (*cc*) Three phases of the same. × 650.
- (*d*) The interlocking dorsal teeth.
- (*e*) The bifurcated plate or fork.
- (*f*) The "membranous area" extending forward beyond (*c*).
- (*g*) Group of three spine-bearing tubules.
- (*h*) Polygonal markings on external surface of lateral walls of labium.
- (*hh*) Interlocking teeth on inner surface of lateral walls of labium.
- (*i*) Bilateral series of ventral spines on labium.
- (*ii*) Ventral aspect of spines. × 850. about.

Fig. 3.—Ventral view of proboscis, flattened. × 260.
- (*a-i*) As before.
- (*j*) Ventral group of scale-like spines between the tips of labella.
- (*k*) Sclerite which covers the arm of the bifurcated plate.
- (*l*, *m*, *n*) Moveable sclerites.



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PROBOSCIS OF GLOSSINA.

EXPLANATION OF FIGS. 4 to 9.

Fig. 4.—Outer aspect of outer wall of tip of labellum. × 580.

(*a*) Large spines.
(*b*) Minute marginal spines.
(*c*) Marginal incisions.
(*d*) The interlocking dorsal teeth.

Fig. 5.—Inner aspect of outer wall of tip of labellum. × 580.

(*a*) Three minute tubules bearing spines.

Fig. 6.—Outer aspect of inner wall of labellum. × 580.

(*a*) Four chitinous jointed rods.
(*b*) Two small spine-bearing rods.

The dotted lines shew the position of rasps and teeth depicted in next figure.

Fig. 7.—Internal aspect of inner wall of labellum. × 580.

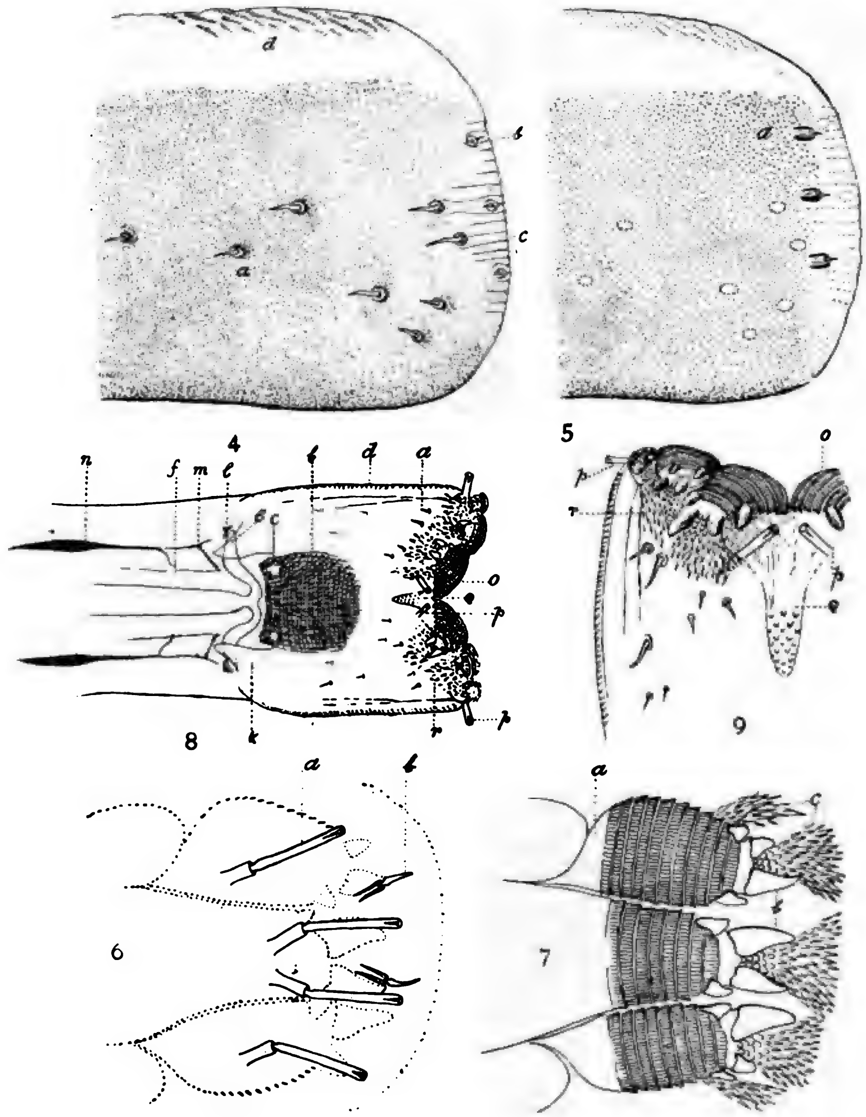
(*a*) Dorsal, middle and ventral rasps.
(*b*) Twelve teeth.
(*c*) Fan-like expansions bearing spines.

Fig. 8.—Tip of proboscis flattened; ventral view shewing position of arms of bifurcated plate and extension outward and ventralwards of the inner plates (Rasps and teeth). × 200, about.

(*a-n*) As before. See Figs. 2 and 3.
(*o*) Rasps.
(*p*) Rods.
(*q*) Ventral group of scale-like spines.

Fig. 9.—Left half of labellum, drawn from same specimen as Fig. 8. × 580.

(*o*) Plate carrying rasps and teeth.
(*p*) Free end of chitinous rods.
(*q*) Ventral group of scale-like spines.
(*r*) Fan-shaped extensions.



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PROBOSCIS OF GLOSSINA.

EXPLANATION OF FIGS. 10 to 16.

Fig. 10.—Section through labella through large anterior teeth on internal plate. × 850.
(*a*) The teeth.
(*b*) Scale-like spines at the commencement of the fans between larger teeth.
(*c*) Chitinous rods.

Fig. 11.—Section through basal pair of teeth and commencement of rasps. One side only shewn. × 850.

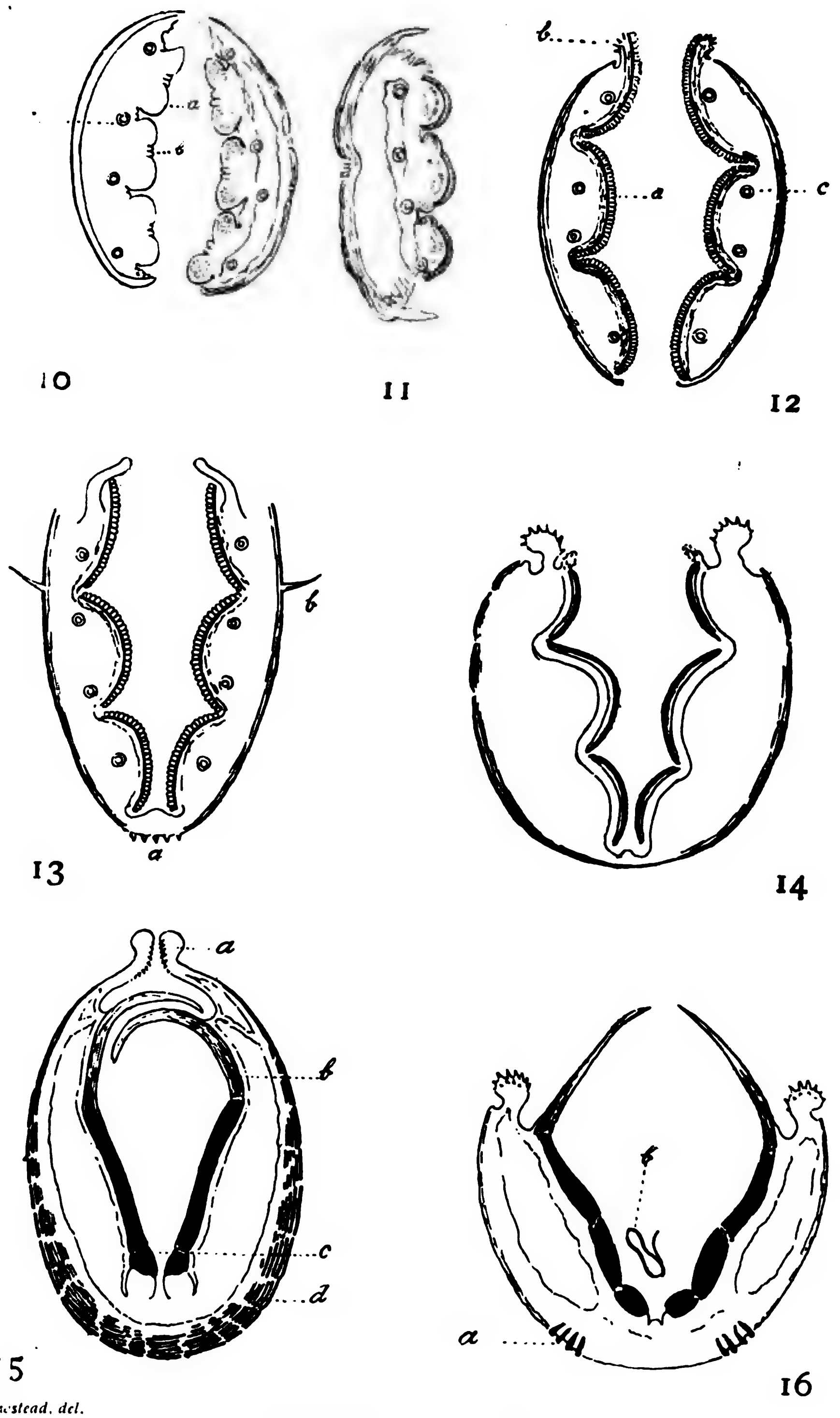
Fig. 12.—Section through rasps. × 850.
(*a*) Rasp.
(*b*) Interlocking dorsal teeth.
(*c*) Chitinous rods.

Fig. 13.—Section through base of rasps. Dorsal aspect imperfect. × 850.
(*a*) External ventral group of scale-like spines.
(*b*) Spines on external wall of labella.

Fig. 14.—Section below the level of the rasps. × 850.

Fig. 15.—Section through dark area. × 850.
(*a*) Dorsal teeth almost interlocked.
(*b*) Sclerites, three on each side of inner wall.
(*c*) Groove between basal sclerites in which hypopharynx (not drawn) lies.
(*d*) Thick ventral wall.

Fig. 16.—Section through membranous area of labella. × 850.
(*a*) Two tubules in section. The spines are not shewn.
(*b*) The hypopharynx displaced from its groove and the investing membrane broken.



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PROBOSCIS OF GLOSSINA.

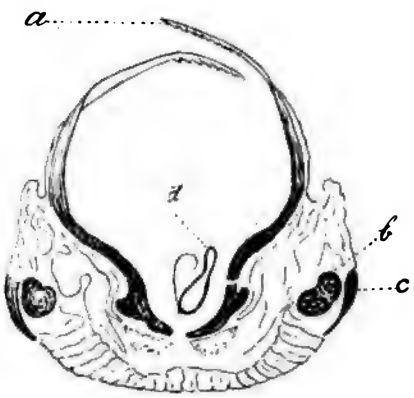
EXPLANATION OF FIGS. 17 to 20.

Fig. 17.—Section through the arms of bifurcated plate. × 850.
(*a*) First appearance of teeth on inner wall of internal sclerite.
(*b*) Tip of fork.
(*c*) Posterior extremity of chitin of dark area.
(*d*) Hypopharynx displaced and the investing membrane broken as in Figs. 18, 19, 20.

Fig. 18.—Section through handle of bifurcated plate. × 850.
(*a*) Arm or handle of bifurcated plate.
(*b*) Tendinous longitudinal band cut across.
(*c*) Ventral band of muscle.

Fig. 19.—Section through anterior portion of labium proper. × 850.
(*a*) Membranous junction of sclerites.

Fig. 20.—Section about the middle of proboscis. × 850.
(*a*) Labrum displaced.



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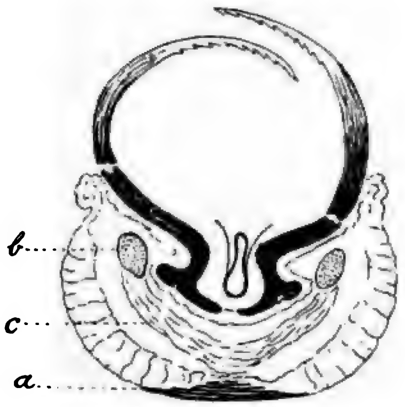

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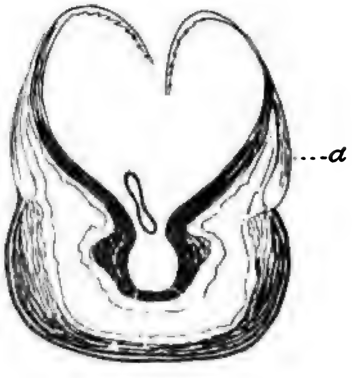

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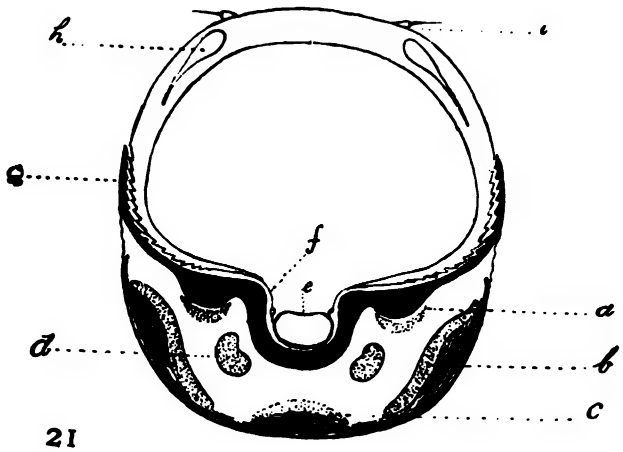
PROBOSCIS OF GLOSSINA.

EXPLANATION OF FIGS. 21 to 23.

Fig. 21.—Near the beginning of the bulb. Schematic section. × 850.
(*a*) Dorsal pair of muscles.
(*b*) Lateral pair of muscles.
(*c*) The unpaired ventral muscle.
(*d*) The median pair of "tendons."
(*e*) Hypopharynx with lateral appendages attached to labrum.
(*f*) The thin membranous portion of the labrum.
(*g*) The teeth on labrum and labium respectively.
(*h*) Cavity in labrum.
(*i*) Hair-bearing papillæ on external surface.

Fig. 22.—Through commencement of bulb. The chitin of the ventral wall is now continuous. × 850.

Fig. 23.—Section through bulb. The labrum is not yet fused with the bulb. × 110.



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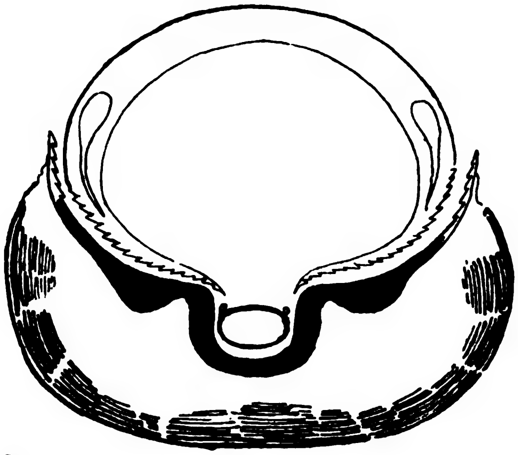

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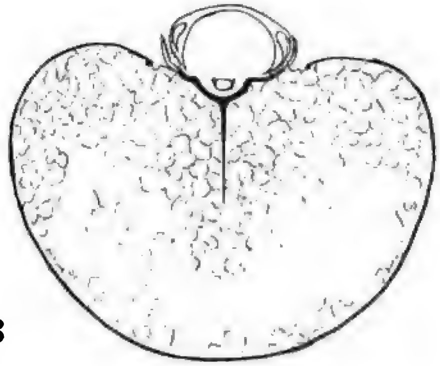

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PROBOSCIS OF GLOSSINA.

EXPLANATION OF FIGS. 24 to 29.

Fig. 24.—Fusion of the labrum with the bulb. × 250.
(*a*) Fine hairs at base of labrum.

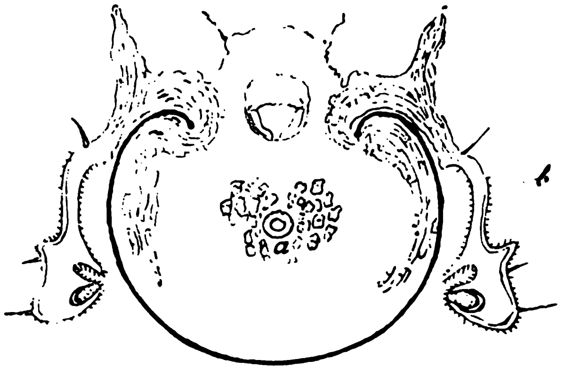
Fig. 25.—Hypopharynx with muscular walls in centre of bulb. × 65.
(*a*) Hypopharynx.
(*b*) Palpus.

Fig. 26.—Shewing commencement of pharynx with chitinous lining. × 250

Fig. 27.—Dorsal view of isolated labrum. × 40.

Fig. 28.—Dorsal view of tip of labrum. × 850.
(*a*) The spines that interlock with those of labium.
(*b*) Apical pair of external hair-bearing papillæ.

Fig. 29.—Right half of basal portion of labrum. × 850.
(*a*) Two rows of external hair-bearing papillæ.
(*b*) Breaking up of rows into irregular groups.



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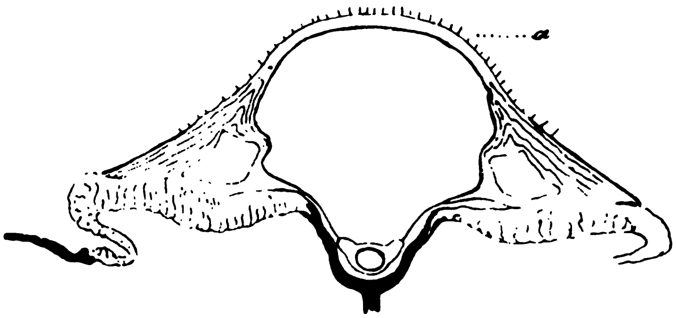

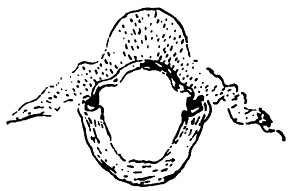

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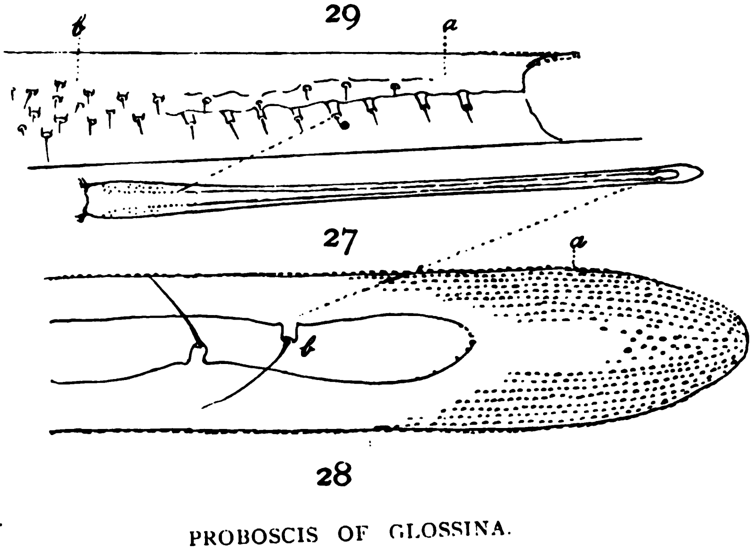

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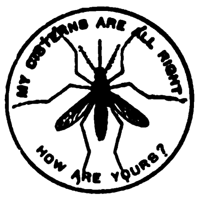
YELLOW FEVER PROPHYLAXIS IN NEW ORLEANS

LIVERPOOL SCHOOL OF TROPICAL MEDICINE—MEMOIR XIX

YELLOW FEVER PROPHYLAXIS IN NEW ORLEANS 1905

BY

RUBERT BOYCE, M.B., F.R.S.



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PREFACE

In this short history of the Yellow Fever Campaign in New Orleans in 1905, I have given an account of the measures which the inhabitants of that City adopted to stamp out the fever. I have made full use of the numerous documents with which I was freely furnished, and I reproduce very many of them with little comment of my own. The evidence shews in a very clear and simple manner how a large city of 330,000 inhabitants, suddenly realising that it was face to face with a serious outbreak, determined without hesitation to put into force the most recent prophylactic measures, to rigidly exclude all the older methods and theories, and to proceed at once to the complete extermination of the Yellow Fever mosquito. In adopting this plan of campaign there was never any hesitation or misgiving, the necessary funds were at once forthcoming, and all classes of the community heartily joined with the medical authorities in the attack. From beginning to end it was a determined effort to rid the City of the Stegomyia pest, and to remove once for all the reproach from the Port of New Orleans that it harboured the mosquito by means of which the disease alone could be propagated. The efforts were completely successful, and shew what can be done by a community, without recourse to force, in a mixed population and labouring under many other disadvantages.

The example of New Orleans, as well as of that of the successful campaign at Havana in 1900, and of the great improvements which have been brought about at Vera Cruz, Rio and other places, should stimulate all nations in the Yellow Fever zone to undertake the extermination of the *Stegomyia fasciata*. Considering the comparative simplicity and inexpensiveness of the methods necessary to be employed, the only excuse for the presence of Yellow Fever in any district must now be attributed to indifference. The practicability of the systematic extermination of the Stegomyia will also, in my opinion, pave the way to a far more determined and scientific effort to get rid of the Malaria-bearing Anopheles, towards which, unfortunately, a large section of mankind seem to have grown tolerant and apathetic, although it is now well known to be the greatest cause of the hindrance to progress in the tropics

PREFACE

I find it very difficult to thank individually the very large group of friends who shewed me so much kindness and gave me so much assistance whilst I stayed in New Orleans. I am deeply indebted to Dr. White, who was in charge of the campaign, to Dr. Warner, Chairman of the Ward Organisations, to Dr. Le Bœuf, the Chairman, and to his Colleagues on the Medical Advisory Committee, and to Mr. Behrman, Mayor of New Orleans. I was brought in contact almost daily with and received great help from the members of Dr. White's staff, and I tender to them my sincere thanks.

I am especially indebted to Dr. Richardson for much advice and assistance. I wish especially to thank my friend Dr. Paul Archinard, who allowed me the use of his laboratory, as also Drs. Matas, Pothier, Jones, Guthrie, Beyer, Perkins and Marks. I beg also to thank, for much valuable assistance, Mr. Janvier, President of the Yellow Fever Fund, Dr. Kohnke, President of the New Orleans Board of Health, Dr. Souchon, President of the State Board of Health, and the Secretary, Dr. Paton. For much personal kindness during my stay in New Orleans, I beg to thank Mr. Le Blanc, Mr. Liversedge, of the Elder, Dempster Company, the Manager of the United Fruit Company, Mr. Donnelly, the Acting British Consul, and many others who all contributed to make my stay in New Orleans of profit. For figures 2 and 6-11 I am indebted to Dr. White.

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YELLOW FEVER PROPHYLAXIS IN NEW ORLEANS

BY

RUBERT BOYCE, M.B., F.R.S.

INTRODUCTION.

IT is not my purpose in this account of the organisation and practical measures by which the epidemic of 1905 was successfully stamped out in New Orleans, to enquire in detail when and how the epidemic arose. This part of the history of the outbreak will, no doubt, be fully dealt with by the Local Health Authorities of the City of New Orleans and State of Louisiana, as well as by the Public Health and Marine Hospital Service of the United States. But I will at the outset, by reason of their practical bearing, take this opportunity of shewing the difficulties which are encountered in such an enquiry.

Previous Epidemics.

In the first place, New Orleans has suffered in the past from many outbreaks of the disease, as the following Yellow Fever mortality Table shews:—

Year.	Number of Deaths.	Year.	Number of Deaths.
1878	4000	1892	0
1879	19	1893	0
1880	2	1894	0
1881	0	1895	0
1882	4	1896	0
1883	1	1897	298
1884	1	1898	57
1885	1	1899	23
1886	0	1900	One suspicious case
1887	0	1901	0
1888	0	1902	0
1889	1	1903	0
1890	0	1904	0
1891	0		

The epidemic of 1878 was very severe, and the total number of recorded cases reached 13,086; in all probability, however, the number was in reality very much greater, the milder cases

passing unrecorded. Those who survived this epidemic were regarded as immunes, and to this fact may reasonably be attributed the long interval of comparative immunity which New Orleans subsequently enjoyed. From 1897 to 1900 the Yellow Fever Returns became again more numerous, 298 deaths being certified in 1897. From 1900 up to the recent epidemic no deaths appear on the list. Thus, whilst the above table shews the liability of the City to Yellow Fever, it also demonstrates that the latter could not be regarded as endemic in New Orleans. This liability to Yellow Fever has arisen from two causes. Firstly, proximity to countries in which Yellow Fever is either endemic or of frequent occurrence, and secondly, presence of the conditions necessary to the propagation of the disease in the City itself.

Relationship of the Trade of New Orleans to Yellow Fever.

The sea trade of New Orleans is very large, and there is a constant intercourse with Mexico, Cuba and the Central American Republics. Ships from Vera Cruz, Colon and other Gulf and Central American Ports have frequently arrived at the Mississippi Quarantine Station or at Ship Island with a passenger or member of the crew suffering from Yellow Fever, or developing the symptoms shortly after arrival in quarantine. The following list compiled from 1905 shews the reality of this method of transport of the disease:—

July 11—S.S. Royal Exchange	from	Colon	1 case
July 12—S.S. Sapphir	,,	Colon	1 ,,
Aug. 6—S.S. Texan	,,	Vera Cruz	1 ,,
Aug. 15—S.S. Puerto Rico	,,	Vera Cruz	1 ,,
Aug. 20—S.S. Sapphir	,,	Colon	3 cases
Sept. 1—S.S. Origen	,,	Colon	1 case
Oct. 26—S.S. City of Tampico	,,	Vera Cruz	1 ,,
Oct. 27—S.S. St. Croix	,,	Vera Cruz	1 ,,

These cases were all detected at the Mississippi Quarantine Station, but the possibility of a sailor or passenger eluding vigilance early in the year and reaching New Orleans and infecting the Stegomyia in the City cannot be altogether excluded. This is not, moreover, the only way in which ships may transfer Yellow Fever, they may also act as the carriers of infected mosquitoes, and although we have evidence that this was of far more frequent occurrence in the old days of sailing vessels than at the present day, there still exists the possibility of this method of mosquito transference. Carter, from

his experience at Ship Island, gives a list of vessels in which cases of Yellow Fever developed on board on their way from Rio, showing that infected mosquitoes were on board, and Dr. Grubbs, from observations extending over five months at the Gulf Quarantine Station on Ship Island, found that out of 82 vessels examined between June 1st and November 1st, of which 78 were sailing vessels and 4 steamers, that 3 sailing vessels contained the *Stegomyia fasciata* on arrival. The mosquitoes had evidently come on board at Vera Cruz, the port of departure; in one of these ships they were breeding in enormous numbers in the water barrels. Dr. Souchon instituted an examination of the fruit vessels during the quarantine season of 1902, and as a result found that out of 12 vessels making 180 trips between New Orleans and Central American ports, the *Stegomyia fasciata* was present 5 times, and on the vessels running between Havana and New Orleans 10 times. There is a possibility, therefore, of the transportation of the infected *Stegomyia fasciata* in ships; at the same time the evidence would appear to indicate that the probability is not very great. Still less appears the possibility of the transference of mosquitoes in baggage (Reed, Grubbs, Gill and Souchon.)

In addition to its vulnerability by sea, New Orleans is also liable to invasion on the land side, and that, too, in spite of rigid quarantine, for everything will depend on the earliness of the application of this measure of defence. The danger, as is well known, arises from cases passing the frontier before the real nature of the disease has been determined and, therefore, before the application of strict precautions. "While simple in theory, land quarantine may prove a very difficult problem in practice, even when backed by an overwhelming public sentiment and ample means." (Report, Louisiana State Board, 1902-1903.)

Conditions obtaining in New Orleans prior to the 1905 Epidemic.

In the second place favourable conditions existed in New Orleans for the concealment and spread of the disease. New Orleans has an estimated population of 325,000, of which 239,000 are white and 86,000 coloured. Owing to the demand for labourers there has grown up a very large Italian and Sicilian population in and around New Orleans which still takes insufficient share in the civic life of

the place. The poorer unassimilated members of this imported population are suspicious and very averse to seeking medical aid, and cases of Yellow Fever occurring amongst them might never have been brought to the notice of the Health Authorities. The district in the neighbourhood of the French Market where they chiefly congregated, and known as "Little Italy," had become very dilapidated. Human beings and animals were herded together in close proximity, the court yards were littered up with rubbish, consisting of rotting wood, tin cans, bottles, and disused tubs, which had been allowed to accumulate during many years, owing equally to the very inadequate sanitary supervision and the absence of a proper system of refuse removal, no doubt also to the habits of the people. No proper drainage existed in the yards, the closets were very dilapidated, and were constructed on the cess pit or pail system. The whole neighbourhood overcrowded, foreign, insanitary, and superstitious, constituted the most favourable nidus in the City for any infective process to take deep root and spread, provided the Stegomyia was also present. Moreover, every yard contained one or more large unprotected water receptacles which gave rise to immense numbers of the *Stegomyia fasciata*, which, after they emerged from the pupa stage immediately sought refuge and blood in the overcrowded living rooms a few feet distant.

In the streets in the older part of the town the sanitation was comparable to the condition of the houses. The paving of the roads was exceedingly bad and irregular (fig. 2), and allowed of the formation of numerous pools after rain. An open drain on each side of the roadway contained for the most part very slowly moving or stagnant putrescent water. The sewage fungus, *Sphærotilus natans*, and the red worm (*Chironomus*) were prominent everywhere where there was the least current. An abundance of solid decomposing refuse partially blocked them up at frequent intervals. Every now and then drains were "cleaned out" and the sludge was deposited on the roadway, often to be allowed to remain on the street till it had been completely scattered, or had found its way back to the drain again. The result of the absence of a proper system of garbage and sewage disposal was the production of an all-pervading odour of sewage, impossible to dissipate in the close and intensely hot summer months.

This condition of affairs contrasted remarkably with the better

MAP I. The infected blocks are most numerous in the old, Italian, quarter of the City.

residential parts of the City where each house had plenty of space around it and where no refuse was allowed to accumulate.

No wonder then that a focus like the above of non-immunes should constitute a serious danger to a large community liable to Yellow Fever. The essential factors were at hand to favour an outbreak; the fever started in this district and had gained a firm hold by July 22nd, when it was officially announced. How long it had been present it is difficult to say; subsequent hunting up of cases of illness would shew that there had been a very considerable number of suspicious cases and deaths, and that these might date from as early as May 13th. One thing certainly is clear, that by July 22nd the infection was not confined to one block, but had already made for itself several foci in the old part of the town. The subsequent history of the epidemic shews that the fever centred amongst the Italians, who furnished the largest number of cases and deaths (Map I). In this connection it is noteworthy to record that in the great epidemic of 1853 the chief sufferers appear to have been the Irish and German labouring population, no less than 3,907 deaths being registered amongst them, whilst only 87 deaths were stated to have occurred amongst the natives of New Orleans.

It will be gathered from these introductory remarks that given the conditions obtaining in New Orleans, it would be very difficult to say when Yellow Fever was introduced, or to lay the blame for the introduction of the disease upon any one place like Belize or Puerto Cortez, through failure of the local medical representatives of the United States to notify the disease at an early enough date. After my stay in New Orleans I had to investigate the outbreak in British Honduras, and subsequently I took the opportunity of visiting Livingstone, Puerto Barrios and Puerto Cortez. I found the same great difficulty in ascertaining with certainty when the disease originated and how it was introduced. Adjacent countries blamed one another. There was little question that, as has been so often the case, the early cases were not recognised and that the outbreak of Yellow Fever was not expected. Upon investigation, I came to the conclusion that great credit was due to the late Dr. Carson, attached to the United States Marine Hospital Service at Belize, for the early and prompt manner in which he acted. Recrimination is of little use: the fact remains that a great Port like New Orleans, with its immense

business interests, was harbouring and breeding every year the *Stegomyia fasciata*, and that it had a large foreign and a growing population living under the most insanitary conditions, and amongst whom it was easy to hide disease. Under such circumstances it was fatal to trust to quarantine alone, no matter how well organised, or how free from Yellow Fever New Orleans had remained for many years.

I now pass to the account of the measures which the people of New Orleans took to stamp out the epidemic; they constitute, in my opinion, the most brilliant demonstration upon a most extensive scale of the application of modern sanitary teaching to the arrest and prevention of Yellow Fever. The example of co-operation and energy which the people of New Orleans set this year should be followed by every town in the Yellow Fever zone with a feeling of absolute confidence that the loyal carrying out of the same measures will eradicate Yellow Fever wherever it is found.

Basis of Yellow Fever Prophylaxis.

The foundation of exact Yellow Fever prophylaxis was laid in June, 1900, by Army Surgeons, Reed, Carroll, Agramonte and Lazear, who were sent to Cuba to study Yellow Fever. In Havana these observers found that already Dr. C. J. Finlay had, as early as 1881, enunciated the theory in no uncertain manner of the propagation of Yellow Fever by the mosquito, and influenced both by this and, as they state, also by the brilliant work of Ross and Italian observers in connection with the propagation of malaria by the mosquito, as well as by certain observations of Carter,* they determined to experimentally investigate this line of research. The results obtained by them were most conclusive. In the same year the Liverpool School of Tropical Medicine despatched Drs. Walter Myers and Durham to study the disease at Para; France followed immediately (late in 1901) with an Expedition composed of Drs. Marchoux, Salimbeni and Simond, which made Rio its headquarters. In 1904 the Hamburg School of Tropical Medicine sent out Drs. Otto and Neumann, who also made Rio their headquarters. In 1903 a Yellow Fever working party composed of Rosenau, Beyer, Parker, Pothier and Francis was sent by the Public Health and Marine Hospital Service to study the

* New Orleans Medical Journal, 1900.

transmission of Yellow Fever at Vera Cruz. Lastly in 1905 the Liverpool School of Tropical Medicine has established for a second time a Yellow Fever Laboratory at Para under the direction of Dr. Thomas, assisted by Dr. Breinl. The conclusions arrived at by these Commissions, as well as by Dr. Guiteras in Havana and Drs. Lutz, Ribas, Barreto, de Barros and Rodriques in Brazil, have all fully confirmed the original observations of Reed, Agramonte, Carroll and Lazear, and have proved that the *Stegomyia fasciata* is the sole transmitter of the disease. The enthusiasm and devotion of this army of workers is shown by the fact that a very large number of the workers suffered themselves from the disease, and that Walter Myers and Lazear succumbed. Reed, one of the most brilliant of this group, unfortunately died at Washington from appendicitis in 1902, hardly before he had had time to witness the beneficial results of his remarkable labours. The flood of new light which was thrown upon the nature of Yellow Fever soon began to have its effect. The first great application of the new principle of prevention of Yellow Fever was made at Havana in 1901 by Major Gorgas, under the very able administration of General Wood. The result was a complete success; it has become historic and constitutes the example to every town in the Yellow Fever zone of the truth of the doctrine of the mosquito transmission and the practicability of its application. The example has been followed; under Dr. Cruz, in Rio, and Dr. Liceaga, in Mexico, great improvements have been brought about, but an immense amount of work still remains to be done. A new stimulus has, however, now been furnished by the successful campaign of 1905 in New Orleans, and it is to be hoped that a great deal of the opposition and apathy still to be met with will soon give place to hearty co-operation and determination to rid Yellow Fever countries of a pest which causes so much suffering and cripples commerce.

PROPHYLACTIC MEASURES ADOPTED BY NEW ORLEANS PREVIOUS TO 1905.

The Mosquito Survey of the City of New Orleans.

Shortly after the brilliant discoveries of Reed, Carroll and Lazear in Cuba proving the connection of Yellow Fever with the *Stegomyia fasciata*, the medical authorities in New Orleans not only commenced to advocate screening and oiling, but a Committee was appointed by the New Orleans Parish Medical Society to map out the mosquito breeding grounds in the City. The results of this investigation have proved of the greatest value to the present campaign (1905). Indeed the work of prophylaxis would have proved far more laborious had not this mosquito survey been made. The localisation enabled the authorities to inaugurate precise and well-directed measures against the Stegomyia without complicating and delaying the campaign in the commencement by an indiscriminate attack on all mosquitoes.

I would strongly advocate as the result of the findings of Havana and New Orleans that similar surveys should be made in all towns subject to Yellow Fever or Malaria.

The New Orleans Parish Medical Society* appointed a Commission in 1901 to investigate the mosquitoes of New Orleans with special reference to Malaria and Yellow Fever. Observations were also made by Dr. Veazie† and by Dr. Dupree,‡ of Baton Rouge, La.

The mosquitoes in New Orleans were, for sanitary purposes, conveniently divided by the Commission into three groups according to their breeding places, viz.:—Cistern, Gutter and Marsh Mosquitoes.

Cistern Mosquitoes.—The examination of 200 cisterns, barrels, troughs, tins found in the yards of houses in different parts of the City yielded the following results:—

Larvæ of Culex pungens	74
Culex stimulans	6
Culex pungens and Stegomyia	20
Culex stimulans and Stegomyia	4
Stegomyia fasciata alone	104
No mosquito larvæ	2

This shows that the *Stegomyia* was far the most common mosquito present. The *Stegomyia fasciata* was in fact the common cistern or house mosquito of New Orleans. It is essentially a town mosquito confined for the most part to

* Bionomics, experimental investigations with Bacillus Sanarelli and experimental investigations with Malaria in connection with the mosquitoes of New Orleans by Prof. Beyer, Drs. Pothier, Couret and Lemann, Jan., 1902.

† ‡ The Mosquitoes of Louisiana and their pathogenic possibilities with remarks upon their extermination. Dr. Dupree. New Orleans Med. and Surg. Journal, July, 1905.

FIG. 1. A Street Gutter in the Suburbs, New Orleans.

FIG. 2. Roadway by the French Market, New Orleans.

the populated centres and less frequently found in the rural districts. Although preferably a cistern breeder it occasionally seeks out other places. The Medical Societies Commission found as the result of an examination of 21 street gutters, the Stegomyia no less than 16 times. If driven by screening and oiling from its usual breeding place in clean water cisterns the eggs appear to be able to develop not only in the contaminated water of the gutters, but even in concentrated fæcal matter (Dupree and others). Reed and Carroll found Stegomyia breeding in

(1) Rain water barrels,
(2) Sagging gutters containing rain water,
(3) Tin cases used for removing excreta,
(4) Cesspools,
(5) Tin cans placed about table legs to prevent the inroads of red ants,
(6) In the collections of water at the base of the leaves of the Agave americana. They state that the presence of fæcal matter is not objectionable. In the map of the mosquito distribution of New Orleans drawn up by the Commission it will be seen that the present epidemic of Yellow Fever corresponds with the Stegomyia distribution.

The Prevention of Yellow Fever, Medical Record, New York, Oct., 1901.

In Belize in British Honduras I found the Stegomyia breeding in immense numbers in the clean water receptacles, such as vats, iron tanks, barrels, kerosene tins and odd receptacles. I also found them breeding in the irregular pockets present in the logs of logwood which, being exposed to the rains, accumulated water. The stained, almost black, water in these crevices did not appear to prevent the development of the wrigglers. I also found them in a cooling water barrel by the side of the furnace in a blacksmith's shop, and the same observation was made in New Orleans during the epidemic. Altogether I examined in conjunction with Mr. Burchell, the Superintendent of Public Works, and Drs. Harrison and Heusner, of Belize, 836 separate lots in the town of Belize, in which there were present 1,342 barrels, 760 vats and tanks, 91 wells, and innumerable kerosene tins and odd receptacles. I took samples of the larvæ, unless the adult Stegomyia was found, and developed them in the laboratory, and, as the result, concluded that the Stegomyia was present in certainly 50 per cent. of the lots in the town. I never found Anopheles in these receptacles, and Culex comparatively infrequently. On the other hand Anopheles larvæ were present in the clean water pools and gutters in the streets and waste places, whilst Stegomyia was absent.

The Gutter Mosquito.

The open gutters, like the system of cisterns, are a feature in New Orleans (fig. 1). As previously mentioned, there is little or no

circulation in them, and they are rich in decomposing animal and vegetable matter. They constitute the breeding grounds of several species of Culex, of which the Commission found *Culex pungens* to be one of the commonest. This mosquito is not, however, confined to the gutters; it is found along the river, in the marshes and in all receptacles which can contain water. It is a very troublesome insect, common all the year round, and bites in the evening and nighttime. Other gutter breeders are *Culex consobrinus* and *Culex stimulans*. Associated with this group is the water-closet mosquito, *Culex impiger*, the larvæ of which require highly-polluted water to thrive in.

The Marsh Mosquitoes—Pools and Drainage Canals.

These comprise, according to the same observers, certain species of Culex and Anophelinæ. Amongst the former are recorded *C. confirmatus*, *C. tæniorhynchus*, and *Grabhamia sollicitans*.

Culex tæniorhynchus is a marsh mosquito, and a virulent biter, which often invades the City in large numbers and produces some dismay on account of its resemblance, in its black and white banded legs to the Stegomyia; the body markings are, however, quite different.

The most widespread breeders in the marshes, and which come only second to Stegomyia in their importance, are the Anophelinæ. As the Map II shews, they surround the City, being present along the river front and in the marsh-land on the sides and in the rear of the town. The Commission describes *Anopheles maculipennis* as essentially a swamp mosquito, never becoming domesticated in large centres of population, where dwellings are standing close together and the soil drained. It exists in large numbers in the outer districts of the City, but is only found in isolated instances in the City. They state that it cannot exist in the cisterns. They regard *A. maculipennis* as responsible for the tertian and quartan varieties of malaria, and the *A. crucians* for the pernicious or æstivo-autumnal fever.

THE STEGOMYIA FASCIATA.

This mosquito, which has been conclusively demonstrated to be the sole transmitter of Yellow Fever, is a very characteristic and familiar one throughout the Yellow Fever zone. It is surmised,

MAP II. Shows the Distribution of the Principal Mosquitoes of New Orleans.

(Reproduced from Report of Commission of Parish Medical Society of New Orleans, 1901.)

FIG. 3. A Water Cistern, New Orleans. It is a breeding place for the Stegomyia and is close to the living rooms.

FIG. 4. Row of Water Cisterns, screened with cheese cloth, New Orleans. This long row of breeding places is close up to the houses.

however, that it was originally imported into the Southern United States from the Tropics through the medium of commercial intercourse. It is common on the coast towns along the Gulf, the Caribbean Sea, and on the Atlantic Coast of tropical and sub-tropical South America, as well as in other tropical and sub-tropical countries.

It is, therefore, a mosquito of the seaports, and this is one of the reasons why it is so essential to eradicate it, especially in view of the continual opening of new fruit ports in Central America and the West Indies. It is capable of flourishing over a wide area, and Dr. Howard, of Washington, states from collected observations that the species can flourish wherever the sum of the mean daily temperatures above 6°C. (43°F.) throughout the year does not fall below 10,000°C. It is not exclusively confined to the coast line, observation showing that in places where it is capable of surviving the winter, it readily spreads into the interior, following the trade routes, whether rail or river. It has already, it is stated, reached an altitude of 4,200 feet in Mexico (Yellow Fever Working Party, No. 1, 1903), and, as shewn by the great outbreak of Yellow Fever in the interior of Guatemala and Spanish Honduras in 1905, it has well established itself along the Puerto Barrios and Puerto Cortez railroads.

It is essentially a domestic mosquito, and, therefore, a mosquito of cities. Whilst the malaria-bearing anopheles is now confined to the outskirts of a large city like New Orleans, having been gradually driven away from the centre of the town owing to the building up of inhabited blocks, and to drainage, the Stegomyia, on the contrary, seeks the central and more crowded parts of the City, the places, in fact, where it finds the necessary and innumerable water receptacles in the closest proximity to the dwelling houses. The knowledge of this characteristic was of the utmost importance in the recent epidemic. It is, indeed, a cistern-breeding mosquito, and is often known on this account as the "cistern mosquito." It is found in abundance, therefore, in those places where rain-water is collected and stored for domestic purposes, no wonder, then, that it was present in New Orleans with its sixty to seventy thousand water vats.

The mosquito is readily recognised by the white bands upon the legs and abdomen, the lyre-shaped pattern in white on the back of the thorax, and the white spots on the sides of the thorax. It is due to the presence of these bands and spots that this black and white

mosquito is often called the "Tiger Mosquito." The females only suck blood, and they appear to attack man both during the day and at night; between 4 p.m. and midnight is stated by some to be their most active period. For this reason it is necessary to take precautions against them at night as well as by day. The Stegomyia is subject to seasonal variations, cold being the great factor in stopping biting activity and breeding. Below 75°F. development is retarded, and the eggs kept at a temperature of 68°F. do not hatch. It is for this reason that the onset of cold weather in New Orleans soon puts an end to Yellow Fever, and that the City is said to enjoy a natural immunity from December to May. Too much stress must not be laid upon this, however, as the fact remains that the mosquito readily survives through the winter. The distribution and history of this mosquito during these months require close investigation, and I trust that again the New Orleans Medical Society will take the matter up. Each female lays between 20 and 75 eggs on the surface of the water; these are minute, black and cigar-shaped; they are very resistant, and have been kept in the dry state for periods varying between 10 and 20 days, and freezing does not destroy their fertility. The eggs are, therefore, a ready means of tiding over the cold weather. Under suitable conditions of temperature the eggs hatch out, according to different observers in from 10 hours to 3 days. The result is the well-known "wiggle waggle," or "wiggle tails," the larval stage of the mosquito. The larvæ are very active and very sensitive, and very rapidly disappear from the surface of the water in the cistern if the least disturbance occurs. For this reason the water-barrel or vat must be approached gently if one is desirous of obtaining specimens and examining them, otherwise they wriggle very rapidly to the bottom. Another point has also to be borne in mind, and that is, that they cling to the sides of the receptacle and hide in the crevices so that it is by no means easy to get rid of them. Simply emptying the water out of the receptacle will not suffice; a very thorough rinsing and cleaning is necessary. The duration of the larval period is from 6½ to 8 days normally; but, of course, they may remain in the larval stage for a much longer period; for instance, I brought some specimens alive to Liverpool which I collected at Puerto Barrios in Guatemala, on October 26th. They were kept in a large test tube either in my pocket or in my living room, and they were exposed to

great variations of temperature, the cold increasing as I travelled from New Orleans to New York and from New York across the Atlantic to Liverpool. The journey occupied 25 days, and they were only supplied with clean water. The larval is succeeded by the pupa stage which lasts two days or under, and from the pupa arises the imago, or winged mosquito.

In comparison with the Culex and Anopheles, Stegomyia larvæ develop very quickly, and this is well seen if bottles containing mixtures of Culex and Stegomyia larvæ are put to develop, the latter will hatch out much more rapidly than the former.

The Infected Stegomyia fasciata.

A knowledge of the following facts are necessary to understand the application of the prophylactic measures which are now employed. The Yellow Fever patient is only capable of infecting the Stegomyia during the first few days of the onset of the disease, the period usually given is the first three days, although the French authorities extend the infective period. The Yellow Fever cadaver is non-infectious; in consequence the separate burial ground for Yellow Fever cases is needlessly harsh, quite unnecessary and unscientific. *At no stage can the Yellow Fever patient or the cadaver infect man directly.* In common with many other non-immunes I was almost daily in the Yellow Fever Emergency Hospital examining patients and assisting at post mortems, but no case of infection ever occurred amongst us. The well-screened Emergency Hospital, although crowded with patients and extremely hot, was, nevertheless, one of the safest places in New Orleans, because the Stegomyia was effectively shut out. No case of direct transmission from the patient to man has ever been recorded. The only one means is through the mosquito, as Ross also proved in the case of Malaria.

When the Stegomyia has taken a meal of blood from a patient in the infective stage it is not at once capable of transmitting by its bite the virus to a healthy individual. *A very definite number of days must elapse before the mosquito is itself infective, and capable of transmitting the virus; approximately this period is twelve days.*

Therefore, at the termination of the period of incubation in the mosquito fresh cases of infection may be expected to occur in those living in a house in which the mosquitoes were not destroyed.

The symptoms of disease will also not declare themselves in man at once, for as just seen in the case of the mosquito, an incubation period is also necessary in the case of man and the *period is usually five days.* Consequently an interval of a little over two weeks usually occurs before secondary cases manifest themselves in fumigated houses.

DIFFICULTIES OF COMBATING THE DISEASE IN THE PAST.

It can be readily understood from the preceding remarks how hopeless and ineffective were the measures of prevention used in the past, and that, too, in spite of the fact that in the more recent periods, Listerian principles of disinfection were applied, carbolic acid and perchloride of mercury being freely used as disinfectants. For instance, although Major Gorgas had, previous to the advent of Reed, Carroll, Agramonte and Lazear, made a vast change in the sanitary condition of Havana, Yellow Fever was, nevertheless, not affected, it only *ceased after employing methods directed against the mosquito, viz.: fumigation and screening.* In Belize, during the recent (1905) epidemic, cases of Yellow Fever occurred amongst the best cared-for class of people living in the best residential houses, where the sanitary arrangements were excellent.

In the past from want of knowledge of the true method of transmission, rigorous house quarantine was enforced in the epidemic of 1878 in New Orleans, and vast quantities of disinfectants were used, clothing and baggage was disinfected or destroyed, but nothing but the frost—the natural means of preventing the activity and breeding of the mosquito—stopped the fever. Ships have been turned away with the dying on board or subjected for long periods to quarantine, thousands of tons of harmless stone ballast have been thrown overboard or disinfected, lest they should spread contagion.

Prejudice against Excavating and Dredging.

Excavations and dredgings from early periods have been regarded with the greatest suspicion, and by a New Orleans Ordinance it is forbidden to make excavations, clean out canals, or tear up the streets from May 1st to September 1st. This Act is a survival of the old theory of miasmata, and it has led to the postponement of most useful operations for the general good of the community. In his

annual report (1902) to the Health Board in New Orleans, the Medical Officer of Health states, "We assert our belief that excavations of soil in summer are innocuous, and we take pride in having been the first to permit work of improvement to continue uninterrupted and unhampered during the summer months." I found in Central America last summer (1905) that considerable prejudice existed against excavations and dredging, and that outbreaks of Yellow Fever were freely attributed to this cause. Needless to say, there is not the slightest scientific foundation for the alarm, and the supposed relationship is in reality an example of odd cases of coincidence. A little enquiry will at once show that Yellow Fever appears in places where no digging or dredging operations are in hand, and conversely, that excavating and dredging may take place every year in a port liable to Yellow Fever without any Yellow Fever occurring. There is no poison in the dredged or excavated material, and it can neither infect human beings nor mosquitoes. The idea probably arises from the fact of the well-known observation that malaria was frequently observed to break out amongst those engaged in canal or railway construction, or in other engineering enterprises on land, or in harbour construction works. In some of these operations terrestrial pools would probably be formed in large numbers and would become the suitable breeding places of Anopheles, but not of the Stegomyia. In any case the bringing together of a number of labourers in a tropical town, living in huts crowded together without any screening of the numerous water containers in order to protect them from mosquitoes, would at once favour the spread of Yellow Fever were it introduced. This has occurred, but is not due to the men turning over the ground or dredging the harbour, but to the fact that they were living under conditions which favoured the propagation of the Yellow Fever mosquito. That this is so a comparison between the monthly mortality on the Panama Canal zone to-day with that of 22 years ago under the old Canal Company is overwhelming proof.

In October 1884, under the French Company, there were 21 deaths and 84 cases of yellow fever amongst 2,706 non-immunes, in a total of 19,243 employees. In October 1905 amongst 4,000 non-immunes, in a total of 22,000 employees, there was no death and only one case.

Efforts to Exterminate the Stegomyia in 1901.

As early as July, 1901, the Board of Health of New Orleans took up the subject of mosquito extermination stimulated by the striking and remarkable results achieved by the Stegomyia campaign in Havana. Conferences were held, lectures given and the householder appealed to. A circular was officially issued to the citizens giving information concerning the life history of the Stegomyia, pointing out the necessity of oiling and screening the cisterns and that oiling should be done regularly. It was further shown that broken bottles, tins and disused tubs were also sources of supply. A certain measure of success attended the issue of these instructions, but soon apathy took place, householders raised objections, and precautionary measures were neglected. The experience acquired demonstrated to the Board "*the inutility of this class of propagandism, unsupported by special law.*" The efforts of the Board were then directed to securing proper legislation, but they were not able to accomplish this until they were in the midst of the present epidemic. It is very greatly to be regretted that in spite of the warning of the Medical Officer and of a large number of the medical men of the City, that little heed was paid to anti-mosquito measures. Had the City then taken effective steps, it would have been spared the recent epidemic. Now, however, the lesson has been learnt, and there can be little doubt that, as the result, New Orleans will become a healthier and cleaner City, and one in which it will be impossible for Yellow Fever, if accidentally introduced, to spread, becoming as secure in this respect as Liverpool or London.

The Prophylactic Measures.

Announcement of the Outbreak.

Immediately after holding an Autopsy upon what proved to be a case of Yellow Fever, the official announcement, that Yellow Fever was present in New Orleans, was made on July 22nd, 1905, in accordance with an Act of 1898 which states that:—"In case any parish town or city, or any portion thereof, shall become infected with any contagious or infectious disease to such an extent as to threaten the spread of such disease to other portions of the State, the State Board of Health shall issue its proclamation declaring the facts," &c.

It is, however, of the greatest importance to note, both in connection with international sanitary rules and with the repeated and most recent pronouncements from Washington upon the absolute necessity of early notification, that on July 12th information had already been conveyed to the Health Authorities (both State and Municipal) by two medical men, of the existence of two very suspicious cases of fever. Dr. Kohnke, the Corporation Medical Officer, immediately investigated the situation, and stated that several days' investigation in the Italian quarters, where the suspected cases came from, "disclosed the presence of infection extending in spots apparently over an area of about five squares; the history of infection dating back several weeks, the character of the disease not being recognised by patients, and attending physicians." During this investigation the Medical Officer gave instructions for fumigation, and upon July 15th communicated the results of his observations to the State Board of Health, describing the prophylactic measures which he had set on foot, and requesting financial aid. As the result of his appeal he was supplied with funds, and orders were issued to commence the more systematic oiling of the cisterns. This was the first step at prophylaxis, but it was local and incomplete.

It is obvious, therefore, that by July 12th the disease had a firm hold of the Italian quarter, that it might well have been present in May, or early in June, and that when the official announcement was made on the 22nd of July of the presence of Yellow Fever, there were, in all probability, a very large number of cases in the City. Indeed, it has been officially estimated that about 100 cases of sickness occurred in the infected quarter prior to July 21st, a large number of which were probably Yellow Fever, and that some 20 deaths took place, of which many were doubtless from Yellow Fever.

In the interval between the 12th and the 22nd suspicion began to be generally aroused, that an outbreak of Yellow Fever was developing in New Orleans. Evidence of this is furnished by the fact that the President of the Medical Society, Dr. Le Bœuf, urged upon the Health Authority, on behalf of the Medical Profession, as early as the 15th the imperative necessity of immediate and stringent precautions.

The First Steps in the Campaign and the Organisation of the Resources of the City to Combat the Disease.

On Friday, July 21st, a meeting of the State and City Boards of Health, the representatives of the Public Health and Marine Hospital Service, and Health Officers from surrounding States, was convened by Drs. Le Bœuf and McGruder in order to reassure the public and to check the stringent and onerous quarantine precautions which had, on the rumours of the presence of Yellow Fever, been promptly taken by the surrounding States against New Orleans, although as yet no official declaration had been made. As an example of this promptitude, it is worthy of note that the State of Mississippi had issued a quarantine ordinance on the day of the meeting. Shortly after the meeting on Friday the first step in general medical organisation was taken by the appointment on the following day, July 22nd, of an *Advisory Board* consisting of the Chairman, Dr. Le Bœuf, and three other members of the New Orleans Medical Society, viz., Drs. Callan, Magruder and Œchsner. This Committee was appointed to co-operate with the Health Authorities and to help to the best of their judgment in the campaign ahead of them. It was now fully recognised by these representative medical men that much valuable time had already been lost, and that the prophylactic measures which had up to this time been adopted by the Health Authorities were neither sufficiently extensive nor precise. I cannot refrain from drawing attention to the fact that during the week or more which elapsed before the official notification was made, that there rests with the Health Authorities during that period, the grave suspicion that this want of prompt notification might have enabled infected Italians and others from the infected quarters to have left the City by steam or rail to spread infection elsewhere. The failure of New Orleans in this respect emphasizes what every International Sanitary Convention had drawn attention to, namely, the necessity of prompt notification of Yellow Fever. Without this, international and interstate sanitary laws cannot be administered in accordance with science, wisely and humanely.

On the evening of the 22nd the Advisory Committee, the Medical Officer of Health, and Dr. White, having deliberated together, issued the first authoritative and collective pronouncement upon the precau-

tions which were necessary to be adopted. The manifesto runs as follows:—

An emergency exists in our City to-day which demands the attention of every individual, with the view to limiting and preventing the spread of epidemic disease. It has been scientifically proved that the mosquito is the only means of the transmission of Yellow Fever, and measures should be especially directed against them. It is especially urged by the undersigned that the following simple directions be followed by the householders of this City for the summer months:—

First.—Empty all unused receptacles of water. Allow no stagnant water on the premises.

Second.—Screen cisterns, after placing a small quantity of insurance oil (a teacupful in each cistern) on the surface of the water.

Third.—Place a small quantity of insurance oil in cesspools or privy vaults.

Fourth.—Sleep under mosquito nets.

Fifth.—Screen doors and windows wherever possible with fine screen wire.

(Signed) QUITMAN KOHNKE,
Health Officer.
J. H. WHITE,
Surgeon, U.S.P.H. and M.H.S.
ADVISORY COMMITTEE,
Orleans Parish Medical Society.

On the same day the authorities, realising that New Orleans was unprovided with a Fever Isolation Hospital, took steps to acquire an old house in the infected quarter in the Italian district. It seems, of course, very extraordinary that in the twentieth century and in a Port of the great importance and size of New Orleans that no proper provision should have existed for the isolation of infectious cases. There is no doubt now, however, after having paid dearly for their experience, that the Citizens of New Orleans will not in future allow this defect to go unremedied.

The Hospital received its first patients on July 26th, and in spite of the fact that it was placed in the midst of most insanitary surroundings and overcrowded, it, nevertheless, answered its purpose very well, owing to the very rigid precautions against the possibility of mosquitoes becoming infected from the patients. It was, indeed, a most striking demonstration of the harmlessness of the disease in the absence of the Stegomyia; several non-immunes, including myself, spent a portion of each day in the wards, but in no instance did infection arise. The entrance to all the wards was barred by double screened doors, so that one set of doors were closed before the second set were opened. A few weeks after the opening of this hospital, it became necessary to change into another temporary makeshift.

This time the premises were larger, more airy and situated amongst more sanitary surroundings. Owing to the fever subsiding it had, however, far less work to do than the former. There is no doubt that the emergency hospitals did magnificent service, and that the greatest credit was due to Dr. Jones, Dr. Paul Archinard, Dr. Guthrie, and to those who assisted them in a most arduous and difficult task, rendered still more trying owing to the hostility of the poorer classes of Sicilians and Italians.

Simultaneously with the formation of the *Medical Advisory Board*, a meeting was held in the Town Hall, under the auspices of the Mayor, of the State and City Health Officers and a number of citizens, prominent in business and in professional life, to review the fever situation, and to raise money. The outcome of the meeting was the successful launching, under the chairmanship of Mr. Janvier, of a Finance Committee—*The Citizens' Yellow Fever Fund Committee*—for the purpose of collecting funds to carry on the fight against the fever. On Sunday, the 23rd, the Rev. Dr. Warner from his pulpit took the first step in Anti-Yellow Fever propagandism amongst religious denominations, and on Monday, July 24th, the 14th Ward of the City organised and met together for the purpose of cleaning up and screening its own district, and for power to issue an advertisement " For bids to screen its 250 cisterns with copper gauze or cheese cloth, and for tenders to clean out the drains." All present at this meeting subscribed to the Ward Funds. Its example was immediately followed by the other wards, and thus was started the *Ward Organisation*, which was subsequently placed under the direction of Dr. Warner.

It will be now simple to trace the steps in the campaign if I follow the work of the several organisations :—

I.—The Local Medical Organisation.

II.—The Ward Organisation.

III.—The Public Health and Marine Hospital Service Organisation.

IV.—The Educational and Press Organisation.

V.—The Financial Organisation.

I.—The Local Medical Organisation.

Appeal for Civic Co-operation.

On Monday, July 24th, a Proclamation is issued, signed by the Mayor, and concurred in by the Medical Authorities, setting forth the situation and calling upon the Citizens to co-operate with the Health Authorities in stamping out the fever. It runs as follows:—

1. *The Mosquito Campaign.*

PROCLAMATION.

Mayoralty of New Orleans,
City Hall, *July* 24, 1905.

To the People of New Orleans:

The Health situation in this City is serious, but not alarming. Because of this situation, quarantine has been declared against New Orleans by several States and Cities. It is proper that the actual facts be recognised and dealt with resolutely and calmly.

It is authoritatively stated by eminent sanitarians that within recent years visitations of Yellow Fever, more widely spread than that which is in our City, have been successfully met and absolutely suppressed by methods whose potency has been demonstrated by ascertained results, and the application of which is simple. Those methods are now adopted by our own State and City Health Authorities, with the volunteer assistance of the United States Marine Hospital Service, and the Orleans Parish Medical Society of this parish. To the perfect and speedy success of the measures to be followed, the co-operation of every householder is necessary. That given, the people may confidently expect a speedy release from the trying conditions in which they are now placed, and from apprehension of its recurrence in the future.

I, therefore, as Mayor, urge all citizens and householders to render cordial and ready obedience to the instructions which may from time to time be given by the Health Authorities, and to render every aid within their power to those Authorities in the earnest efforts which they are now making, and in which they will persist for the absolute stamping out of this infection. Those instructions are not difficult of performance; they are easily to be understood, and can be followed with but little expense. Since the consensus of sanitary and medical opinion of to-day is that the infection of Yellow Fever is transmitted, or can be transmitted, only by means of the sting of the insect known as the "cistern mosquito," the following advice recently given by Dr. Kohnke, the City's Health Officer; by Dr. Souchon, President of the State Board of Health; Dr. White, Surgeon of the U.S. Marine Hospital Service, and an Advisory Committee of the Orleans Parish Medical Society, should be willingly and implicitly obeyed by every householder in this City.

First.—To keep empty all unused receptacles of water in every house, and allow no stagnant water on any premises.

Second.—To screen all cisterns after placing a small quantity of insurance oil (a teacupful in each cistern) on the surface of the water.

Third.—To place a small quantity of insurance oil in cesspools or privy vaults.

Fourth.—Sleep under mosquito nets.

Fifth.—Wherever practicable, screen doors and windows with wire screens of close mesh.

The foregoing advice may from time to time be given by the Health Authorities with more particularity. Whatever emanates from them must be accepted as given

for the good of the City and the preservation of every individual of its population, and should be respected and followed to the letter.

I repeat, upon the information of those qualified from actual investigation and scientific knowledge to speak upon this subject, that the situation in our City is not alarming, and that if it is treated by our people earnestly and intelligently, that this situation will soon be eliminated and demonstration will be made to the world that for the future the infection of Yellow Fever can have no permanent lodgement within the borders of the City of New Orleans.

MARTIN BEHRMAN, Mayor.

We concur in the above.

QUITMAN KOHNKE,
City Health Officer.

EDMOND SOUCHON, M.D.,
President, L.S.B.H.

J. H. WHITE,
Surgeon, P.H. and Marine Hospital Service.

ADVISORY COMMITTEE,
Representing Orleans Medical Parish Society.

2. *Appeal for Early Notification.*

On July 24th a most important notice is also issued to the members of the Medical Profession from the Orleans Parish Medical Society, and signed by the Advisory Committee, Dr. White, the Medical Officer, and the President of the Louisiana State Board of Health urging upon each medical man the absolute necessity of early notification and of reporting all cases of fever. It is unquestionably an exceptionally wise circular and touches a very weak spot. I reproduce it :—

ORLEANS PARISH MEDICAL SOCIETY,
NEW ORLEANS, LA.,
July 24, 1905.

DEAR DOCTOR,

We want to specially urge you to report all your cases of fever--malarial, typhoid fever or fever of any kind—during this summer, to the City Board of Health. It is absolutely essential to the checking of the spread of Yellow Fever in our City that all cases of fever should be promptly and conscientiously reported. Our patients, the public and the surrounding communities, will naturally look to our profession in this great emergency, and the responsibility rests in a great measure with us to check this condition, or at least to limit its too extensive spread. It is a well-known and scientifically proven dogma that the mosquito theory is to be accepted as a fact ; then we must exert ourselves to the utmost to destroy the mosquito, the only host of transmission of Yellow Fever. Let us, then, make a consistent campaign against it, educate our patients regarding this situation and the danger of it, and direct them to place patients immediately under netting pending action of the Board of Health. Neither your patient nor the household will be subjected to the obnoxious house quarantine of several years ago.

Above all things, REPORT YOUR CASES PROMPTLY, to permit us to check any further foci of infection.

Even if you are not positive that the mosquito is the only source of transmission of Yellow Fever, give your City the benefit of the doubt in this important and vital matter. Respectfully,

EDMOND SOUCHON, M.D.,
President, Louisiana State Board of Health.
QUITMAN KOHNKE, M.D.,
Health Officer of the City of New Orleans.
J. H. WHITE, M.D.,
Surgeon, U.S. Public Health and Marine Hospital Service,
in charge of the Government Measures.
ADVISORY COMMITTEE, ORLEANS PARISH MEDICAL SOCIETY,
John Callan, M.D., John F. Oechsner, M.D.,
M. J. Magrudger, M.D., L. G. Le Bœuf, M.D., Chairman.

3. *Appeal for Immediate Screening of Suspected Cases and Fumigation.*

This circular is speedily followed by another to the medical men, again urging the importance of early notification and careful fumigation. As regards the method of fumigation the circular is not so stringent upon this subject as subsequent experience found to be absolutely necessary to ensure safety.

ORLEANS PARISH MEDICAL SOCIETY,
DEAR DOCTOR, NEW ORLEANS, LA.

In an earnest attempt to work in harmony with the plan of procedure adopted by the Health Authority, and the U.S. Public Health and Marine Hospital Service, now being enforced in a general inspection of our entire city, we want to suggest to you, as your Advisory Committee acting with these bodies, that you report at once any case of fever in your practice remotely suspicious of being Yellow Fever. If you want to do your City the greatest good in this hour of trial, immediately constitute yourself as a Health Officer for the premises of the sick you are called to attend. Even before the regular Sanitary Inspector of the Board reaches the house, place the patient at once under a mosquito bar, pending further proceedings. Also order at once another room fumigated with sulphur—two pounds to the 1,000 cubic feet—and then thoroughly screen it. If it cannot be done in a perfect manner, at least order all the openings screened with either cheese cloth or other light material, well packed so as to allow no mosquitoes in the room. Keep only one door free, covering all the transoms in the same manner. On entering this door beat the air thoroughly with a cloth before opening. When the room is prepared, remove the patient to it, fumigating the room just vacated in the same manner.

After the first three days of the fever the Stegomyia fasciata cannot be infected from that patient, but we must be careful to keep the room well closed until the final fumigation or destruction of any mosquitoes which might have remained in the room. Look to the general hygiene of the house, inquire whether the cisterns or any other open receptacles of standing water about the premises have been properly oiled or screened. Act in this matter regardless of the work which will be done by the constituted authorities, for your own personal good and for the greatest good of your City. In other words, Doctor, take every possible precaution to protect all of your fever cases from being bitten by mosquitoes during the first three days of fever.

Our interest in this entire matter is the same as yours, and we must work for the same purpose. The part to be played by our profession is an extremely important one ; the faith and trust of the entire community is placed on our shoulders, and we must fully deserve the confidence reposed in us.

Very sincerely yours,
ADVISORY COMMITTEE, ORLEANS PARISH MEDICAL SOCIETY.

4. *Appeal for an Educational Campaign.*

Another circular is issued on the 24th, directed to the Board of Health, pointing out the necessity of a Campaign of Education, and urging the importance of asking the Clergy to especially disseminate knowledge from the pulpit in the matter of Yellow Fever. The circular then proceeds to give useful information in case of infection and finally appeals for united action in a general warfare against the Stegomyia.

NEW ORLEANS,
July 24th, 1905.

GENTLEMEN,

The condition existing at present is one that calls for the most strenuous, prompt and vigorous measures capable of institution. In view of the absence of the necessity for obnoxious local or house quarantine, the co-operation of physician and householder should be a matter of comparatively easy solution. A campaign of education should be boldly inaugurated. The clergyman, during his rounds and from his pulpit, should be a valuable agent in the dissemination of this knowledge. The Advisory Committee of the Orleans Parish Medical Society begs to recommend that the following measures be instituted at once, with the view of stamping out the few foci of infection of Yellow Fever which now exist in our City.

Cases of fever of any character developing in the infected area may be regarded as suspicious, and the patient immediately protected from mosquitoes. The house, cisterns, yards, drains, gutters, cesspools and vaults should be carefully inspected, and no breeding spots for mosquitoes should be overlooked.

The gutters and streets must not be neglected.

If the case proves to be one of Yellow Fever, the house must be screened and the rooms in the house other than the one occupied by the patient must be fumigated, to destroy all mosquitoes in them. When the case ends, either by recovery or death, the room occupied by the patient must be fumigated, for the same reason.

The success of these procedures will largely depend upon the promptness and earnestness with which mosquitoes are prevented from coming in contact with the patient and the destruction of all mosquitoes in the room after the patient is cured or dies.

The new foci of infection must be diligently sought and drastic measures adopted for stamping them out. It is only through the proper conciliatory education of the physician and the layman, and through their sincere co-operation, that anything can be accomplished.

For the vast portion of the City not infected, we recommend that a sufficiently large force of men be immediately organised to place oil in all unscreened cisterns, or other breeding places of mosquitoes, and distribute circulars amongst householders enlisting their co-operation.

All gutters should either be flushed or oiled.

An active, vigorous and persistent warfare on mosquitoes should, in our opinion, be immediately instituted from one end of the City to the other, as in this way localities now healthy may be kept so, even though foci of infection be introduced. We believe that the sanitary regeneration of this City depends entirely upon prompt and vigorous action on your part.

With the profoundest assurance of our heartiest co-operation with you in any movement to better the sanitary conditions of the City,

We beg to subscribe ourselves,

ADVISORY COMMITTEE, ORLEANS PARISH MEDICAL SOCIETY.

5. *A Warning to beware of the Danger of overlooking the less obvious Breeding Places of the Stegomyia.*

A very useful and practical notice is also sent out by the Advisory Committee directing attention to the importance of not overlooking possible receptacles of water in the house, as pitchers, flower pots, &c. It reads as follows:—

ORLEANS PARISH MEDICAL SOCIETY,
NEW ORLEANS, LA.

We desire to call your special attention to the wrigglers seen inside of the residences of people. Probably the public in the fight against the mosquito have directed all their efforts against the cisterns and the barrels or the outside containers, still a source of great danger also exists inside of the bedrooms in the water-pitchers, in the dining-room, or in the conservatory in the water-pots, vases or pots for plants. A frequent error and a great menace is the habit which some householders have of only partly emptying a water pitcher, and though it is refilled daily it is never emptied entirely, leaving always one-half pint or so for the larvæ to develop. Any physician in his daily rounds can see this illustrated by inspecting the various water-pitchers in the bedrooms.

On this same line we beg to again call your attention to the accumulation of water in the Urns in the Cemeteries as well as in the sagged gutters of the house drains, which are a great source of mosquito breeding after rain.

6. *Appeal for a more Skilled Medical Body to conduct the Campaign.*

Upon August the 4th, the fever still making headway in spite of all local efforts, the Advisory Board takes very decided action. It candidly expresses the opinion that it has not confidence in the efficacy of the work performed up-to-date; *that this work must be absolutely perfect in its working to be efficient*, and that to accomplish the desired re-organisation it is necessary to call in the assistance of the Public Health and Marine Hospital Service of the United States.

NEW ORLEANS,
August 4th, 1905.

CITY BOARD OF HEALTH.

GENTLEMEN,

As there has appeared a new case in the Frye focus, which has been in existence since Monday, while we had been told that the instructions previously agreed upon in the management of all maturing foci had been rigidly carried out, and especially so in this case. As we are not satisfied that the fumigation performed by the City Board of Health has been absolutely effective, we feel, as we have shared some of the responsibility of this work, that it is a matter of too great importance to be kept on in this unorganised and unsystematic manner. This is the first serious visitation of Yellow Fever in this country since the mosquito has been recognised as the only mode of transmission, and we are unwilling to support the City Board of Health in what we consider an ineffective service.

We regard this as the first crucial test in America, and it must be absolutely perfect in its working to be efficient. We think that the community has lost confidence in this work. We know that the profession has lost faith in it. Hence, we cannot keep on upholding a system in which we do not fully concur, so we desire to strongly recommend that the system be completely reorganised, or that the entire Yellow Fever situation in New Orleans be placed in the absolute control of the United States Public Health and Marine Hospital Service.

Very respectfully yours,

(Signed) ADVISORY COMMITTEE, ORLEANS PARISH MEDICAL SOCIETY.

As the result of this letter and of a telegram despatched to the President of the United States, the Public Health and Marine Hospital Service assume, in a few days, control of the campaign. The Advisory Committee, however, continue their useful work and co-operate with the new forces under Dr. White, just as they had done with the Local Health Authorities, continuing to issue with Dr. White most useful circulars, and to generally encourage in every way the citizens to keep up the fight with unabated vigour. As the circulars which they issued show a thorough knowledge of the situation and great foresight I give them in full.

7. *Letter warning Medical Men not to overlook the Mild Type of Yellow Fever which may be found in the native born.*

ORLEANS PARISH MEDICAL SOCIETY,
NEW ORLEANS, LA.,
August 17, 1905.

DEAR DOCTOR,

In the consistent campaign we are now waging throughout the City against the fever we want to enlist your hearty assistance.

You have shown up to now a uniform activity, and if some of the work already accomplished begins to show some little improvement, we feel it is greatly due to your co-operation. This though, is the crucial moment, and you must keep up reporting all your cases with unfailing promptness. *The native born will undoubtedly begin to be affected, and will show the lightest and mildest types of the disease; it is specially with regard to these, that we wish to warn you, for it is as important to the success of the work being done by the U.S.P.H. and Marine Hospital Service, that the mild cases be reported as well as the marked cases. These must be screened as carefully as others.*

One stegomyia infected, in the first three days from such a case, can produce a number of serious and even fatal cases. The means employed are being systematized and rendered less objectionable daily by the service, so let us endure a little inconvenience for the welfare of all.

Beware of the so-called immunization or acclimatization fever and report these cases as promptly and rigidly as if they were perfectly characteristic, so that the authorities will be able to give them the same SANITARY TREATMENT.

Very earnestly yours,

ADVISORY COMMITTEE, O.P.M S.

8. *Appeal to Householders to delay "Moving Day" on account of Danger of Spreading Infection.*

In view of the near approach of "Moving Day" (October 1st) the undersigned deem it their duty to direct your attention to the danger likely to attend a general moving of tenants from house to house.

Persons moving from infected localities may later develop the fever in uninfected neighborhoods, thereby developing new foci. Others now residing in uninfected houses may contract the disease by removing into houses where mild cases of fever may have occurred and recovered without Medical Attention, and consequently escaping fumigation. Non-immunes coming into such houses will almost inevitably contract Yellow Fever, thereby adding to our present troubles.

We do therefore urge the importance of taking such steps as may be necessary to delay the general movement for at least thirty days.

ADVISORY COMMITTEE, O.P.M.S.

9. *Danger of Removal of Temporary Cistern Screens.*

NEW ORLEANS PARISH MEDICAL SOCIETY,
NEW ORLEANS, LA.
Sept. 13, 1905.

There being a pretty general understanding in the community that the cheese cloth screens over cisterns have to be removed by Oct. 1, and the regular 18-mesh to the inch wire screen substituted by that date, we believe that a number of persons are now having this change done to the great danger of a general liberation of all mosquitoes imprisoned or bred from the pupæ in the cisterns. We can not afford, in the final fight of checking Yellow Fever in our midst, to neglect so important a matter as this, so we strongly urge that the change from cheese cloth to wire, if not legally postponed until Dec. 1, shall be by having the wire screens placed over the cheese cloth without removing the latter.

ADVISORY COMMITTEE OF ORLEANS PARISH MEDICAL SOCIETY.

II.—THE CITIZENS' ORGANISATION.

It was mentioned in an earlier part of this history of the organisations that a Citizens' meeting was held on July 21st, in the Town Hall, for the purpose of raising funds, that Mr. Janvier was appointed Chairman of the the Yellow Fever Fund Committee, and that on July 24th the first step in Ward organisation was made by Ward 14. A further step was taken on July 26th when the Advisory Committee, together with the Health Authorities, decided to place the organisation of the 16 Wards of the City under the charge of one man. They selected Dr. Warner, who, by his devotion, energy and personality soon won the confidence of all classes of citizens, and made them work as one man.

The Citizens' Volunteer Ward Organisation.

On July 28th the Central Office of this splendid organisation was opened under the direct charge of Dr. Warner, and under the guidance of the Advisory Committee. Dr. Warner immediately set to work and issued a circular to all the Wards, calling upon those who had not already organised to do so, to open offices in each Ward, and asking each what it proposed to do. A meeting was also summoned of the Chairmen of each of the Ward organisations to deliberate on the best plan for co-ordinate action.

The 16 Wards took up the work with enthusiasm. Each Ward held numerous meetings and planned its line of action in the campaign against the mosquito. Each took charge of the sanitary operations of its district, commenced screening and fumigating, and purchased stocks of cheese cloth, lime, oil, oilers, pasting materials and ladders to reach to the top of the cisterns. Each one organised the necessary gangs requisite for inspecting, screening, fumigating and oiling. Each Ward also issued public notices and posters drawing attention to the necessity of fumigation, &c. Finally they commenced an educational campaign of the greatest magnitude. Under Dr. Warner's administration the organisation set to work to educate the whole population; numerous meetings were held every night in the various Wards, in the churches of all denominations, schoolrooms, halls, clubs, &c. The audiences were addressed by medical men especially chosen for their expert knowledge, by leading citizens, by the Mayor, Dr. Warner, the Bishop and numerous other citizens. The City Health Officer was especially active in giving almost every night to large audiences a lantern demonstration of the life history of the Stegomyia, throwing upon the screen by means of the lantern the " wiggle waggles " kept alive in a water cell. This was always a popular and useful demonstration and should be copied extensively. The lectures were given in English and other languages, and no section of the very mixed population of New Orleans was left out. All religious denominations co-operated with remarkable alacrity, and lent their churches and organisations to the lecturers. The coloured people were organised and many meetings were held amongst them. At first it was difficult to overcome the prejudice of the Italian and Sicilian people, but by using influence with their own priests, and leading men, they, too, became more amenable. The

campaign was thus in the hands of the Ward Organisation which received its expert advice from the Advisory Board. In the emergency it supplemented and largely replaced the City Health Board.

It was an excellent organisation and brought about an immense awakening of the people in the matter of sanitary reform. When finally the Advisory Committee, as previously mentioned, saw that the fever gained in spite of the energy of this civic organisation, owing to lack of sufficient trained and official medical officers to direct, and that it was necessary, therefore, to appeal to Washington for the Public Health and Marine Hospital Service, and when, in consequence, the Service did take charge, the latter immediately placed its own marine medical superintendents in charge of each of the Ward offices, and simply co-ordinated, drilled and extended the ward machinery; in this way it ensured perfect co-operation.

Before entering upon this final stage of the campaign, I would like to draw attention to some of the Proclamations and Notices which were issued both during the period when the Ward Organisation was in sole charge of the campaign, and subsequently when it was under the supreme authority of the Marine Hospital Service. The first two which I insert are official notices from the civic authority and are signed by the Mayor. The first one is a most useful water screening ordinance, and constituted a most powerful factor in bringing about the suppression of the disease. It is one which should be extensively copied.

1. *A Water Cistern Screening Ordinance.*

MAYORALTY OF NEW ORLEANS,
CITY HALL, *Aug.* 2, 1905.

NO. 3196 NEW COUNCIL SERIES.

AN ORDINANCE, prescribing the manner in which water liable to breed mosquitoes shall be stored within the limits of the City of New Orleans.

***Section* 1.—Be it ordained by the Council of the City of New Orleans that no water liable to breed mosquitoes shall be stored within the limits of the City, except under the following conditions.**

***Section* 2.—Water kept in cisterns, tanks, barrels, buckets, or other containers for a period longer than one week shall be protected from mosquitoes in the following manner. Cisterns shall be covered with oil by the property owner or agent thereof within forty-eight hours after the promulgation of this ordinance and provided with a cover of wood or metal; all openings in the top or within six feet of the top larger than one-sixteenth of an inch to be screened with netting of not less than eighteen**

mesh, or cheese cloth or other suitable material by the property owner or agent thereof within forty-eight hours after the promulgation of this ordinance, provided that after the first day of October, 1905, all property owners shall be required to screen cisterns with wire netting of the proper size mesh as required by the Board of Health in such a manner as to prevent the entrance of mosquitoes.

Section 3.—Tanks or barrels or similar containers to be constructed in the manner provided for cisterns, or in some other manner satisfactory to the Board of Health.

Section 4.—Buckets containing water for longer than one week (such as fire buckets in cotton presses) and other similar containers of stagnant water, shall be covered in such a manner as to prevent the entrance of mosquitoes.

Section 5.—Water in ponds, pools, or basins, in public or private parks, places of resort or residences, or in depressions, or excavations made for any purpose, shall be stocked with mosquito-destroying fish, or covered with protective netting, or shall be drained off at least once every week, or shall be covered with coal oil in a manner satisfactory to the Board of Health, by the owner or agent thereof within forty-eight hours after the promulgation of this ordinance.

Section 6.—The Board of Health may, in its discretion whenever deemed necessary, treat stagnant water by applying oil to its surface in such a manner as to destroy mosquitoes.

Section 7.—The penalty for violations of this ordinance or any section thereof shall be a fine of not more than twenty-five dollars, or imprisonment for not more than thirty days, or both, and failure to comply with any provision shall be considered a separate offence for each day of its continuance after the proper notification by the Board of Health.

Adopted by the Council of the City of New Orleans,
August 1, 1905.

T. W. Campbell,
Clerk of the Council.

Approved Aug. 2, 1905.

Martin Behrman, Mayor.

2. *A Day Appointed to "Clean up" in the City.*

The following is an appeal to the Citizens to "clean up," and it again should be copied by all towns in the Yellow Fever zone:—

The Mayor's Proclamation.

It has come to be recognised as an indispensable necessity for the eradication of disease, and for the proper safeguarding of our public health, that our City should be thoroughly cleaned. Our patriotic citizens are unanimous in the sentiment and have generously come forward to aid and assist in such a movement.

The Executive Committee which was named to consider and take action upon the thorough cleansing of the City, recommended that Wednesday, August 9, 1905, be observed as general cleaning up day. To that end, and to promote the more expeditious handling of the accumulations of dirt, it has been recommended that all householders begin the work of cleaning their premises Monday, and continue the same Tuesday, in order that the refuse and pilings will be ready and convenient for removal Wednesday, "General Cleaning Up Day."

It has been earnestly and urgently recommended that all merchants and business men assist in this work by closing their respective establishments on that day, so that

they and their employees may assist in the task. There have been many patriotic offers of carts, wagons, teams and drays, and all contractors who are engaged in work of public improvement are urged to contribute their teams to aid in this laudable undertaking of removing trash and pilings. The details of this work will be planned and prepared under the direction and control of the Commissioner of Public Works, to whom the tender of carts, teams, &c., must be made as soon as possible in order that the full programme may be perfected and made public not later than Tuesday morning.

In furtherance of this great object, I do hereby call upon every taxpayer and householder to extend every assistance towards the effective performance of the work, and urging that all merchants and business men close their respective establishments on that day, I do hereby proclaim Wednesday, Aug. 9, 1905, to be "General Cleaning Up Day."

Witness my hand and seal of Office, affixed this fourth day of August, A.D. 1905.

MARTIN BEHRMAN,
Mayor.

3. *Appeal to the Clergy.*

CITIZENS' VOLUNTEER WARD ORGANISATION,
NEW ORLEANS, LA., *July* 29, 1905.

TO THE REVEREND CLERGY:

The influence of the Reverend Clergy is such, and their loyalty and public spirit has been so often demonstrated, that we venture to ask your co-operation with the Citizens' Volunteer Organisations in the present emergency.

United action produces the surest results.

We beg to ask that you will speak to your congregations on Sunday, July 30th, or at the earliest date thereafter convenient to yourself in behalf of the work now being carried on by the Health Authorities of the City.

We ask that you will urge them, whether they believe in the "mosquito theory" or not, that they will give their hearty assistance to the authorities who are attempting to stamp out the mosquito, as at least one source of infection. Urge upon them the patriotic duty of allowing cisterns to be oiled and screened; cesspools to be treated with disinfectants, &c.

Many householders (a small minority but still enough to work mischief) refuse permission to the oilers and screeners to do the work. This refusal nullifies to a great extent the work accomplished on the premises of willing householders. In previous visitations of the fever we have been fighting in the dark, striking at an unknown enemy coming from a mysterious source.

The consensus of scientific opinion fixes upon the mosquito as the agent of transmission of the Yellow Fever.

The enemy therefore is in sight. So far as your power extends then, we beg of you to use it for the spread of information concerning the mosquito theory, and to use your influence with your congregations to hold up the hands of the constituted Health Authorities.

This office will gladly receive suggestions and will give all possible assistance to the Ward Organisations.

It is proposed to have two cleaning up days, by proclamation of the Mayor, although this has not at this writing been definitely decided.

The daily newspapers will announce it when determined. We will ask you to bring this matter also to the attention of your congregation.

Faithfully yours,
BEVERLEY WARNER,
General Superintendent.

4. *Charity Organisation during the Epidemic.*

The Charity Organisation Society has been designated by the General Superintendent of the Citizens' Volunteer Ward Organisation to receive and disburse such money and supplies as shall be contributed for the relief of the sick and poor people whose sufferings may be due to the present visitation of Yellow Fever.

The Society is fully organized, with permanent headquarters, perfected machinery, competent investigators, and an intimate knowledge of the poor of this City.

We appeal to all good citizens for money for the "Emergency Fever Fund," pledging ourselves that every dollar so contributed will be sacredly devoted to the help of those to whom the Yellow Fever, and its accompanying hardships, have brought suffering.

We have no funds in hand except twenty-five dollars received from Mrs. Christian Keener. Receipts will be published from time to time.

MICHAEL HEYMAN,
President of the Charity Organisation Society.

I beg to endorse this appeal most heartily, and to ask our citizens to make the above Society the channel of their contributions to the fund for general work of relief which we may be called upon to undertake.

While we do not seek to interfere with the charitable work of the churches and benevolent organisations, but to co-operate with them, we wish to sound a note of warning in time. Emergencies like the present are rich opportunities for the charity "grafters." The misfortunes of the sick and poor are made the capital of the lazy and worthless.

The Charity Organisation is better equipped than any other I know in New Orleans to deal with this important side of the volunteer work, and this office heartily endorses the above appeal.

BEVERLEY WARNER,
General Superintendent.

Ward Notices.

The following notices, from one of the Ward Offices and distributed to Householders in the Ward serve as examples of the useful work which they did.

Request to the Householders of the Ward to observe a General Fumigation Day.

FIRST WARD CITIZENS' SANITARY ASSOCIATION,
1749, ST. CHARLES AVENUE,
NEW ORLEANS, LA., *September* 1, 1905.

TO THE CITIZENS OF THE FIRST WARD.

Saturday, Sept. 2, and Sunday, Sept. 3, have been suggested and agreed upon as GENERAL FUMIGATION DAYS, between the hours of 10 a.m. and 12 a.m., for the purpose of destroying the mosquitoes, which are recognised as the medium of communication of Yellow Fever, and we make the following suggestions as to the manner of fumigating :—

1. Close all outside openings, such as doors and windows, and make the house (or room) to be fumigated as tight as possible, by closing or stopping the fireplace and other openings, with paper pasted over them.
2. Pianos should be removed from the rooms to be fumigated.

3. Place an iron vessel, flat skillet preferred, in pan or tub with about one inch of water in it; place roll of sulphur or flower of sulphur (two pounds to each ordinary sized room to be fumigated) in the skillet; pour over it a small quantity of alcohol, about two tablespoonsful to the pound, and set fire to same.
4. Keep the house, or rooms, closed for two hours after lighting the sulphur.

Those who prefer to do so may use Pyrethrum powder (insect powder) instead of sulphur. Where this is used the rooms should be swept after the fumigation and the mosquitoes so gathered up should be burned, as Pyrethrum powder merely stuns the mosquito. The amount of Pyrethrum to be used is one pound to each ordinary sized room.

We quote the following from Rev. Beverley Warner, Superintendent:—

"In conformity with the urgent request of the Marine Hospital Surgeon in command, and on behalf of the Volunteer Ward Organisations, your representatives, I earnestly recommend a general fumigation of the houses, stores, office buildings, factories and every harboring place of the mosquito, on Saturday, September 2, and on Sunday, September 3, in the case of those who find that a more convenient day.

"Respectfully,
"BEVERLEY WARNER,
"General Superintendent."

Residents of the First Ward can procure sulphur for fumigation free by applying at any of the places named on the back hereof. The citizens of the First Ward have, up to now, manifested their intelligence by solidly supporting the authorities, both our own local health officers and those of Marine Hospital Service since they have taken charge, by implicitly following their directions and suggestions in the fight that has been, and is being made, against Yellow Fever and its disseminator, the mosquito. The good resulting therefrom is shown in the diminution of the number of new cases since the fumigation of last week and the week before, although they were not as general as they should have been. The good results from the sanitary work done in the First Ward by its people, and their general compliance with the recommendations of the Health Authorities is demonstrated by the comparatively small number of cases of the fever which have appeared in our ward.

We strongly urge you to fumigate on Saturday, or Sunday, in compliance with the above request, and thus assist in stamping out the fever and ridding our City of the mosquito which transmits it.

Respectfully,
C. TAYLOR GUACHE,
President of the First Ward Citizens' Sanitary Association.
W. J. BRADY,
Secretary.

SULPHUR DEPÔTS.

Boebinger's Grocery ....St. James and Tchoupitoulas.
Neupert's Grocery ....Tchoupitoulas and Orange.
Manning's Grocery ....Tchoupitoulas and Theresa.
Twohig's Grocery ....Market and Chippewa.
Huber's Grocery ....St. James and St. Thomas.
McLaughlin's Grocery ....Felicity and St. James.
Corbett's Grocery ....Orange and Constance.
Holmes' Grocery ....Terpsichore and Constance.
Holmes' Grocery ....Camp and Melpomene.
Abradie's Grocery ....Prytania and Euterpe.

Moore's Grocery	St. Thomas and Race.
Moore's Grocery	Race and Religious.
Feahney's Grocery	Melpomene and Constance.
Burn's Grocery	Felicity and Religious.
Labruyere's Grocery	Race and Constance.
Altmeyer's Grocery	Annunciation and Robin.
Heimel's Grocery	Baronne and Melpomene.
Heimel's Grocery	Rampart and Melpomene.
Decourcey's Grocery	Thalia and Baronne.
King's Grocery	Dryades and Thalia.
Lacey's Grocery	Robertson and Melpomene.
Bornsel's Grocery	Melpomene and Howard.
Erlinger's Grocery	Thalia and Liberty.
Corondona's Grocery	Mongolia and Melpomene.
Geary's Grocery	Melpomene and Howard.
Wilson's Grocery	Liberty and Felicity.
Carroll's Grocery	Claiborne and Melpomene.
Dowie's Grocery	Terpsichore and Saratoga.
Second Precinct Police Station	Chippewa and Terpsichore.
Ward Headquarters	1749, St. Charles Avenue.

SCREENS.

IMPORTANT. READ CAREFULLY.

TO THE RESIDENTS OF THE 12TH WARD.

The good work of all residents in the 12th Ward has called for much attention by the press and public. All cisterns have been oiled and screened, gutters oiled several times, and many of the houses fumigated, but we must not rest or stop one minute.

We must kill every mosquito that breeds Yellow Fever, and hasten the end of the fever by stamping out every spot in the ward where mosquitoes can breed.

We must continue to oil the gutters whenever necessary. The cheese cloth around the cisterns are being torn and broken daily by the wind, and providing places in which the mosquito will breed, and it should be corrected at once. In order to help the good work and stop this means of breeding mosquitoes,

YOU ARE REQUESTED AND URGED TO COVER YOUR CISTERN WITH NOT LESS THAN 18 MESH WIRE AT ONCE, AND WITHOUT FURTHER DELAY.

There is ample wire now here to do this, and a few dollars spent now to correct the bad screening will make the work permanent and save many lives.

ALL CISTERNS MUST BE SCREENED WITH WIRE BEFORE OCTOBER 1ST.
THAT IS THE LAW.

Don't get the wrong wire, if you do it will have to be done over again, and in order to show you what 18 mesh wire is we call your attention to this picture showing the size, 18 holes to the inch.

Don't wait until October 1st, and perhaps have an affidavit made against you, followed by a fine, and perhaps imprisonment : while you have time.

DO IT NOW. THE SOONER, THE BETTER FOR ALL.
12TH WARD SANITARY ORGANISATION.

III.—The Public Health and Marine Hospital Service Organisation.

On August the 4th, at a meeting at which the Mayor, the President of the Orleans Parish Medical Society, and the representatives of all commercial bodies in the City were present, it was decided to ask the United States Government to take control of the Yellow Fever situation. Accordingly messages were immediately transmitted by the Governor of Louisiana and the Mayor of New Orleans, to the President of the United States, asking the Federal Government to assume control of the health situation and pledging the hearty co-operation of the State and City Government, the State and City Health Boards, the Parish Medical Society, and of the merchants and people generally. The request was gladly complied with and Dr. White, who represented the Public Health and Marine Hospital Service, and who had, from the commencement of the outbreak, been watching and co-operating with the local organisations on behalf of the Federal Government, took complete charge from August 7th, and in the course of a few days, having collected a staff of twenty trained Marine Hospital Service Surgeons, promptly set to work to strengthen the organisations and increase the stringency of the Anti-Yellow Fever measures.

Functions of the United States Public Health and Marine Hospital Service.

In view of the great services which this body rendered the cause of public health in 1905, a few remarks upon its history and function are not without interest at this stage. The Service was constituted in 1798 for the purpose of the care of disabled sailors at ports in the United States. In 1875 under the able guidance of Surgeon-General Woodworth, the Marine Hospital Service expanded its functions and took an active share in quarantine and local health administration. Shortly afterwards the Service became the authority upon quarantine administration, and the services which it rendered to commerce on account of its wise reforms began to be widely appreciated. In 1878 it organised the first medical expedition to gather information upon Yellow Fever, and thus set an example which has been a feature of this useful service. In the same year national quarantine was established, and the Marine Hospital Service

was appointed to frame regulations and to supervise. Simultaneously Consuls in Foreign Ports were instructed to report to the Surgeon-General the existence of contagious diseases. The Service was also empowered to publish weekly bulletins upon health and to transmit them to their officers and to other public health bodies. After this date the expansion of the public health duties of the Service rapidly increased. The Surgeon-General instituted an inspection of all State and Local Quarantine Boards requiring them to conform to the law, whilst under the Immigration Acts all incoming aliens had to be examined by the Marine Hospital Service Officers for physical soundness. At a number of ports the carrying out of quarantine was handed over by the State to the Central Machinery of the Federal Government. In certain instances, however, the national Government through its Public Health Service assumed charge because of the non-compliance of the local authorities with the law.

A number of States still conduct their own quarantine, and whilst the Federal Government takes care that the quarantine law is strictly administered it has no right to prevent a state or local authority adding additional and often onerous quarantine measures to the minimum standard which the Federal Government regard as efficient. This has, in the case of New Orleans, been brought prominently forward in 1905, and the opinion has been freely expressed that in the interests of safety and commerce there should be exclusive national control. The present dual system is complex, and moreover, as the local authority exacts fees, whilst the Federal Government does not, commerce would gain. A great feature of the Marine Hospital Service is the Staff of Surgeons, who are stationed at various foreign ports with which the United States is in trade relationship, and also the number of surgeons who are available for sending to places, like New Orleans, when an emergency arises. In their very varied professional duties both abroad and in the United States, the Surgeons of the Marine Hospital Service gain a very considerable experience not only in treating infectious diseases such as Yellow Fever and plague, but also in dealing with men of all nationalities and in hunting out disease. They wear a military uniform, and the business-like and determined way in which they set about their appointed work unquestionably inspires confidence. This

was certainly the universal opinion in New Orleans during the epidemic. Another feature of the Marine Hospital Service is the encouragement which is given to research. At the headquarters of the Service in Washington there is a Bureau of Hygiene in the Laboratories of which investigations are continually taking place in infective processes, preventive medicine, parasitology, pharmacology and bio-chemistry. From time to time also expeditions are sent abroad to study tropical diseases such, for instance, as Yellow Fever. The representatives of the Marine Hospital Service stationed in foreign towns, notably in the important fruit ports in Central America and in the West Indies, have very important duties assigned to them. They keep the Central Government at Washington informed of the Health conditions of not only the ports in which they are stationed, but of the surrounding country in addition. Thus they are the first to cable to Washington the outbreak of quarantinable diseases. They also exercise a very beneficial effect in the ports in which they are stationed, and their services are often made use of by the local authorities. Thus during the epidemic of Yellow Fever last year in many of the Fruit Ports in Central America they took the lead in organising anti-stegomyia measures.

From the foregoing remarks it is clear that the title "Marine Hospital Service" does not indicate the wide functions of this body, and, indeed, in 1902 the Service was confirmed by Law as a National Public Health Service of the United States, and it was enacted that in future it should be known as the Public Health and Marine Hospital Service.

Description and Progress of the Campaign under the New Organisation.

With great tact Dr. White took over the local Ward organisations, which, as we have seen, had already accomplished a great deal, and were in fair working order. He placed at the head of each Ward a Marine Hospital Surgeon. In the originally infected quarter he formed a special Depôt in charge of Surgeon Berry, and together with Surgeons Richardson and Lazard as his assistants, he established his own headquarters in the centre of the City. The plan of campaign was that which had already been adopted by the Ward

organisations, only now it was carried out with renewed energy and precision. It consisted in:—

1. Discovering every case of Yellow Fever and isolating it.

2. Killing all Stegomyias.

3. General warfare against all mosquitoes, except swamp.

4. Ensuring that each Ward was fully equipped with its forces of inspectors, oilers, screeners, fumigators and others as wanted, and that there was an adequate number of men.

Each Ward Office was in telephonic communication with the Central Office.

Under the Marine Hospital Surgeon in each Ward were placed one or more medical assistants, young local medical men, chosen on account of their local knowledge and ability, and a staff of workmen, varying from 28 to 128.

Each Ward Centre was furnished with a supply of—

Fumigating Materials—Sulphur, pyrethrum, pots for fumigating, paper, paste, laths and all accessories for sealing.

Screening Materials— Bobinette and sheeting, wire, portable wire screened doors, ladders, nails, hammers and all accessories.

Oiling Materials— Oil and oil cans, ladders, scythes for cutting rank grass, carts.

A map of the district was kept in each Office and the progress of the cases, the number of cisterns oiled, and of houses fumigated were recorded with dates. The various gangs, whether inspectors, oilers, screeners or fumigators, left the Ward Offices early in the morning for their appointed tasks, or at such time as they were particularly required. A practitioner might report a case to the Central Office or directly to the Ward Office in which the case occurred. If in the former manner the Central Office telephoned to the Ward Officer concerned. As the result of the call, a screening and fumigating gang (fig. 6) would be despatched, the patient's room would be screened and the rest of the house fumigated, or the patient would be removed in the ambulance (fig. 5) to the Emergency Hospital, and the house fumigated. Depending upon circumstances the surrounding blocks would also be fumigated, and from the tenth to the thirtieth

FIG. 5. The Screened Emergency Hospital Ambulance, New Orleans.

FIG. 6. A Screening Gang about to start to screen a room containing a yellow fever patient, New Orleans.

(*From Report on Yellow Fever, British Honduras, 1905.*)

day of the occurrence of the case the Medical Inspector would visit the house every day to locate any secondary cases.

The work of the Central Office consisted in directing the work of the Wards, receiving reports of cases, preparing and issuing reports and instructions, and in generally organising. For these purposes a large clerical staff, as well as a statistical department and accountants' office, were necessary. All cases of fever had to be notified to this Office, and it was in constant receipt of innumerable complaints and questions. Every morning either Dr. White or Dr. Richardson made an inspection tour of the districts. It was soon found necessary in order to check unnecessary expenditure to establish a *purveyor's office.* This was placed in the charge of Dr. Perkins and a staff of about twelve assistants. Each Ward was required to send in a requisition to this department for the material it wanted, which, if not in stock, was promptly obtained. In this way waste was avoided, and by purchasing supplies beforehand in the cheapest markets, considerable saving was effected. The office was most carefully organised and everything was reduced to a very precise system.

Total Number Employed in the Campaign.

Total number of men, inspectors, oilers, screeners &c....	910
Special Fumigating Division	156
Special Investigating Division	105
Purveyor's Department	32
	1,203

The total Medical Staff was fifty, of which twenty were Marine Hospital Service Surgeons.

Boards of Consulting Experts.

A body of twenty-three experienced medical men were chosen amongst the various wards, who were available at any time for consultation upon difficult or suspicious cases.

During the first few days after the Marine Hospital Service was officially placed in charge of the campaign, Dr. White was busy meeting the Presidents of the Ward organisations, placing his own

officers in charge of the Wards, instructing them in their duties, and holding daily conferences with the various representative bodies.*

On August 11th he met the Presidents of the Ward Organisations and agreed upon the following general plans:—

That the work of the Ward Organisation must be carried on as strenuously in the future as in the past.

That there should be a "mosquito killing day" throughout the City once a week, when the entire population should make an effort to kill by fumigation the mosquitoes in their houses.

That all the street gutters should be flushed out once a week.

That every Ward undertake a complete minute inspection of all cisterns in its territory to see that they are perfectly screened.

That as an extra precaution the oilings of all cisterns be continued.

That only oil of at least 150 flash test be used so as not to render water unpleasant.

That all physicians and everyone else in the City report to headquarters every suspicious case they might learn of.

A feature which struck me as one well worthy of particular note was the degree of freedom of action which he allowed to his officers, and the trust which he placed in their intelligence, commonsense, energy and loyalty. I can certainly say from my close observation of this confidence in his juniors that it worked admirably, the sense of freedom which the younger officers possessed, in my opinion, contributed to their feeling the responsibility thrown upon them, and to their taking an intense personal interest in the progress of affairs in their Wards. There existed a complete sense of brotherhood between seniors and juniors, and all felt it to be their paramount duty to make a success of the campaign. In spite of the fact of the intensely hot and close days of August, and that their chief work

* For example, on August the 8th, at a meeting convened at the residence of Bishop Sassums, of the representative Laity, Clergy and Medical Men, he gave the following practical hints, viz.:—That during the epidemic the ladies should not visit unnecessarily. That they should not go out unless business called them. That they should not leave home unless for Church or for actual necessary shopping. That they should not wear low quarter shoes. That they should not go into their neighbours' homes unnecessarily. That they should not go out without a veil, and that they should not go out without gloves as both were a protection against Stegomyia.

He also exhorted the medical men present to report all cases of fever. "If you have a case of fever and it is a bit questionable, set aside all your professional pride and call in an expert to see if it is not a mild case of Yellow Fever. *A little child may have a light fever for twelve hours, pass off, and the family physician say it was nothing.* That child may be bitten by mosquitoes, and in about twelve or fifteen days the whole family may be taken down with violent cases of Yellow Fever. That is why I appeal to the family physicians to help us. One mild case that you are not inclined to call Yellow Fever, or not report, may be responsible for 100 cases.'

was in the slums, they worked with untiring energy and set a most stimulating example to all classes of citizens. The ultimate success of the campaign is due to their skilful handling of the operations, and is the best demonstration of the importance of employing energetic, young and thoroughly well-trained medical men to combat epidemics. If England proceeded in the same determined way to attack Malaria, which is still the great cause of sickness and mortality in her tropical possessions, the disease could be got under and a complete change brought about in the conditions of life in the Tropics, a change, moreover, which would completely alter most of the present conditions of commerce.

Every day of the campaign increased the experience of the Ward officers, and the organisation became more and more perfect. They had to feel their way in the commencement, but later their operations were directed with the greatest precision, leading, as we shall see, to the limitation of the fever in October, practically after two months strenuous work.

I will now insert some of the circular notices which were issued to the ward officers and others, as they are eminently practical, and a good guide for future operations of a similar kind.

1. *Formation of Inspecting, Oiling, Salting and Screening Squads.*

This is a circular letter issued from the Central Office on August 16th, by Dr. White, and embodying a letter of recommendations drawn up by Dr. Metz. It reads as follows:—

PUBLIC HEALTH AND MARINE HOSPITAL SERVICE.
OFFICE OF MEDICAL OFFICER IN COMMAND,
NEW ORLEANS, *Aug. 16th*, 1905.

SIR,

There should be attached to the officer in charge of the Ward, as many inspection squads as will be necessary to cover the territory in his charge as quickly as possible; after the ward has been fully inspected there will be need of one or more squads to re-inspect the district at certain intervals. These inspectors will fill out the report blank which will be furnished them. They will also issue notices to owner, agent or occupant to clean premises, empty privy vaults, order the screening or re-screening of cisterns should the same be required.

The foreman of each squad should be a special officer, commissioned by the Mayor, in order to enforce compliance with the order issued in the name of the Board of Health of the City of New Orleans, and the U.S. Public Health and Marine Hospital Service, and these men sworn into the service.

There should also be attached to the officer in charge of a ward, one or more oiling

and salting gangs to see that all empty lots holding stagnant water, should be salted, and all gutters which are stagnant should be thoroughly salted.

In order that there shall be no conflict between the Citizens' Volunteer Ward Organisations and the U.S.P.H. and M.H.S., I would suggest that the following shall be the basis of this understanding.

The Volunteer Ward Organisations shall have such squads as may be attached to the headquarters of such ward organisations by the Central Headquarters of the Citizens' Volunteer Ward Organisation. These squads will receive their instructions from the U.S.P.H. and M.H.S. Officers in charge of said ward, report to him the specific work done, and the premises at which the work was done.

The report shall be made in duplicate, one copy for the U.S.P.H. and M.H.S. and the other for the Central Headquarters of the Citizens' Volunteer Ward Organisation

UNIT.

For Labour and Material needed for one Screening Inspection Squad.

1 Foreman.
2 Labourers.
Wagon.
2 ladders (extension).
3 hammers.
2 carpenters' aprons.
5 pounds of tacks.
1000 yards of cotton cloth, preferably sheeting.
2 pairs of shears.
1 gallon oil can.
3 sacking needles.
2 balls of twine.
Scratch pads.

The above is fully approved, and all Officers in Division Command will please take note of this matter, will select the number of men necessary for their work, after consultation with Dr. Metz, and they and Dr. Metz together will select the foreman. Each foreman will be ordered to report to the Mayor's office, at a time designated by Dr. Metz, to be sworn in. Dr. Metz will then do everything in his power to aid in the perfection of this plan, the details of which he will explain to any officer who does not understand the idea.

Respectfully,
J. H. White,
Surgeon, P.H. and M.H.S.

2. *Necessity of Hourly Reports from the Wards to Headquarters.*

Public Health and Marine Hospital Service.

New Orleans, *August 17th*, 1905.

Gen. Orders.

1. Officers in charge of wards are directed to communicate each hour with the Central Headquarters, for the purpose of securing reports of cases in their respective wards, so that immediate action may be taken in the way of screening and fumigating.

2. The daily lists of all reported cases will be mailed from these Headquarters to each ward, as heretofore.

J. H. White.

3. *Directions for Pyrethrum Fumigation.*

PUBLIC HEALTH AND MARINE HOSPITAL SERVICE.

NEW ORLEANS, *August 18th*, 1905.

GENERAL ORDERS.

1. Officers in charge of fumigation are directed to use pyrethrum powder, in the proportion of 2 lbs. to 1,000 cubic feet in the preliminary fumigation of houses in which patients are actually sick at the time the fumigation is done.

2. In using pyrethrum, great care in pasting on the inside of the room all cracks and crevices is necessary, and all save one exit should be pasted before lighting the pyrethrum.

3. After pyrethrum fumigation, it is necessary to sweep and dust the various rooms fumigated with care, burning at once all sweepings.

4. The object of this fumigation is to reach, at the earliest possible moment, all mosquitoes which may have bitten the patient, and without irritation to patient and relatives.

5. Pyrethrum packed in 5 lb. packages can be secured from the Purchasing Agency.

J. H. WHITE.

4. *Upon the Imperative necessity of Reporting Suspicious Cases.*

This is a very important circular letter which was issued to the Medical Profession of New Orleans urging the importance of reporting all fevers where the diagnosis is not clear.

PUBLIC HEALTH AND MARINE HOSPITAL SERVICE.

NEW ORLEANS, *August*, 1905.

DEAR DOCTOR,

Considering the imperative necessity of instituting at the earliest possible moment prophylactic measures in the case of any person, suffering of a fever which may subsequently be shown to be Yellow Fever, you are urgently requested to report to this office not only any case of fever which you may be sure is Yellow Fever, but also ANY CASE YOU MAY BE UNABLE, even at your first visit, to say is not Yellow Fever.

We enclose you cards which will facilitate your report of such cases, and will at the same time give us your authorization to inspect the said premises and to do whatever may be necessary to prevent the extension of the infection in the house or neighbourhood.

We give you our assurance that your rights as the attending physician will be fully respected, and that our inspectors will make no attempt to examine the patient or in any manner endeavor to influence your diagnosis or treatment of the case.

We shall await your final determination of the case, but hold ourselves ready to serve you with a consultation free of charge to your patient from the enclosed list of gentlemen, who have consented at our request to aid this office in the clearing up of any doubtful diagnosis.

Feeling sure you will understand the spirit which prompts this communication—the desire simply to get the co-operation of the entire profession of this City in the checking of the multiplication of the new foci of infection and the early destruction of those already existing,

I am, very truly yours,

J. H. WHITE.

5. *The Institution of a Systematic Sanitary Survey of each Ward ordered.*

MEDICAL OFFICER IN CHARGE OF WARD.

NEW ORLEANS, *Aug.* 21, 1905.

SIR,

It is the purpose of this office to have a sanitary survey of each ward.

To carry this scheme into effect, it is necessary for you to inspect the ward under your control, with the least possible delay. It is not the intention of this office to interfere with your organisation, but to give you the necessary aid to carry the work to its rapid completion. You may, however, have to detach some men from some of your squads temporarily, until the inspection is completed. As soon as the sanitary survey in your ward is completed you will reduce the number of men to the minimum required by you to carry on the duties which have been assigned to you.

For example, in ward organisation consisting of, say, eight gangs of one foreman and two men each, might be just right, or it might need to be supplemented by four or more additional gangs. A ward with eight gangs of eight men each could be reduced to an average or uniform basis by making, say, sixteen gangs of four men each, it being my idea to reduce the inspection gangs to one foreman and two men each, and have as many gangs as necessity demands.

You are requested to make all necessary arrangements, in order that the work of inspection can be inaugurated by Wednesday morning, to this end you will engage the necessary labor. If you have intelligent men who can act as foremen in your service and in whom you have confidence, send their names at once to this office and instruct those men to report at the office of the Mayor on Tuesday morning at 10 a.m. (Aug. 22, 1905) for the purpose of swearing them into service as Special Officers. Should you desire more men as foremen this office can furnish those required.

When these foremen are no longer needed to perform the duties of Inspectors, you will ask them to surrender their Commissions and badges, and you will return them to this office, that they may be delivered to the Mayor.

The pay of a foreman will be $2.00, and the pay of the laborer will be $1.50 per day of hours.

The duties of the foreman of an inspection gang (and in which you are ordered to instruct them) will be :—

(1) To make an accurate report of all conditions as specified in the Blank Forms furnished ; and of all work done.

(2) The foreman will be required to serve notices on the tenant when the cistern is insufficiently screened, and to report to the medical officer in charge the names of all parties having unscreened cisterns ; to notify tenants that filled privy vaults shall be emptied within 48 hours under penalty of the law.

(3) The work to be done by the inspection gang shall be to repair slight defects in the cistern screening ; to empty all receptacles containing stagnant water unless protected. To oil wells that are not protected, and pits or privy vaults which can not be emptied.

(4) Material necessary for the repairs of cistern screens, as enumerated in Circular Letter of Aug. 16th, can be had upon requisition through the proper bureau.

Respectfully,

J. H. WHITE.

6. *No Divided Authority in New Orleans.*

PUBLIC HEALTH AND MARINE HOSPITAL SERVICE.

NEW ORLEANS, *August* 22, 1905.

TO OFFICERS IN CHARGE OF WARDS.

As there seems to be some misapprehension on the part of the Officers in charge of the various Wards, relative to their duties and responsibilities in the matter of the sanitary survey of the City which is to be undertaken (concerning which Circular Letter dated Aug. 21st was addressed to them), all Officers are informed that they are in full charge of all measures in their several Wards; that there is no division of authority, and that the work contemplated in the Circular Letter above referred to will be under their sole supervision, and will be conducted along with, and in addition to, their other duties.

J. H. WHITE.

7. *Beware of False Remedies.*

Comment upon the following is unnecessary.

PUBLIC HEALTH AND MARINE HOSPITAL SERVICE.

NEW ORLEANS, *August* 22, 1905.

TO THE PRESS OF THE CITY OF NEW ORLEANS.

While under ordinary circumstances I would not pay any attention at all to the claims of Dr. R. B. L., I feel that under present conditions when every effort is being directed towards the eradication of Yellow Fever in the City, along rational lines, and when the hearty co-operation of all citizens is necessary to the success of this effort, it is inadvisable to allow the attention of the people to be drawn away from proper methods and devoted to the discussion of fads, and, in order to demonstrate that this claim is not based on proper scientific efforts I submit the following facts :—

In February, 1898, this same man submitted to Congress a memorial in which he claimed, by this same arsenization method, to render persons immune, not only to Yellow Fever but to cholera and bubonic plague. This memorial was submitted to the then Surgeon-General of the U.S. Army, George M. Sternberg, one of the foremost medical men in the world, and by him pronounced to be without rational basis, and an adverse report was rendered by the Committee on Public Health and National Quarantine in the United States Senate.

The second statement I wish to make is that no remedy could be a sovereign specific for three several diseases differing from one another so tremendously as plague, cholera and Yellow Fever. It is manifestly a fact that so-called "cure-alls" cure nothing.

Finally, there are in this City several undoubted cases of Yellow Fever in the practice of physicians of high repute, and one in the Emergency Hospital itself, in all of which cases the patient had been subjecting himself to arsenization in accordance with the Leach method. This statement can be easily substantiated whenever it becomes necessary.

Respectfully,

J. H. WHITE.

We, the Advisory Committee of the Orleans Parish Medical Society, concur in the above opinion.

8. *Salting of Stagnant Gutters and Pools ordered.*

This order was issued on August 23rd, for the purpose of killing any Stegomyia which might possibly be breeding in the gutters. Subsequent experience, however, I think demonstrated that this material although efficacious against the Stegomyia was not strong enough to prevent the breeding of the Salt Marsh mosquitoes which became troublesome. Crude oils were more efficacious if used in sufficient quantity.

U.S. PUBLIC HEALTH AND M.H.S.

NEW ORLEANS, *Aug.* 23, 1905.

SIR,

A car of rock salt will be placed at , for distribution in the stagnant gutters and pools in your Ward. The wagons and labourers necessary for distribution of this salt are employed by contract from the Central Office. As soon as possible the distributing forces will report to you for directions as to the manner and place of distributing the salt, this being under your direction.

You will please institute at once a rapid survey of the streets of your Ward, so that you may have a definite idea where to place the salt, and will detail one of your foremen to supervise the distribution.

It is calculated that the average gutter 1 foot wide and containing approximately 4 to 6 inches of water will require 500 lbs. of salt. To the front of a Block, the salt should be placed only in those gutters and pools that are stagnant, and which cannot be flushed out.

J. H. WHITE.

9. *Instructions for Fumigation for Foremen of Gangs.* (*figs.* 7-9).

These most practical and eminently characteristic directions were issued by Dr. White on August 29th, that is after gaining considerable experience in this most difficult of all the Anti-Yellow Fever measures to carry out efficiently.

1. Assemble gangs in morning, note vacancies, if any, and ask for necessary men to keep gangs up to full strength.

One man in each gang must be able to speak Italian.

2. Foremen must supervise the collection of supplies before starting out in the morning. Supplies taken out must be counted, and will be checked up against them.

The following supplies are necessary:—Sulphur, alcohol, pyrethrum, flour or paste, paste brushes, tacks and hammers, scissors, oil can, roll paper, large and small sizes, cotton batting, and pots and pans.

Especial care must be used in selecting pans; a leaky pan may cause much damage to carpets, matting or floor.

3. Assignment of houses for fumigation must be carried out in the sequence in which they are given to the foremen, unless for good reason.

The foremen are responsible for discipline in their gangs. Drinking during working hours, idling and loafing are sufficient causes for instant dismissal.

4. On arriving at a house for fumigation, the foreman is to act as spokesman, and must not allow members of his gang to "butt" in. The interpreter to be used freely in order that there may be no misunderstanding. No promises must be given that

FIG. 7. Steam Fumigating, New Orleans.

FIG. 8. Fumigating Gang at work, New Orleans.

(From Report on Yellow Fever, British Honduras.)

FIG. 9. Papering Archways, New Orleans.

FIG. 10. The Oiling Gang, New Orleans.

(From Report on Yellow Fever, British Honduras, 1905.)

only one fumigation of the house will be required. It may be necessary to fumigate a house several times, depending upon the amount of infection in the neighbourhood.

5. If permission to fumigate is not secured, ascertain reason. If because of sickness, endeavor to get permission to fumigate such part or parts of the house as will not disturb the sick. This is difficult, and sometimes impossible in a small cottage, but can be easily done in a large three-story house, for instance. In this case the rear or front of the house can be done, and if the patient is not critically ill, the other floors of the house can be done. Insistence is not urged in any case, if the patient is critically ill or actually moribund. If the patient has died or recovered, no excuse must be taken for not fumigating the whole house at the same time. In case of such refusal, or other refusals where there are no sick at the house, such refusal is to be immediately reported to the Ward Office by telephone or messenger.

6. Where premises to be fumigated are entered by the foreman and his gang, he is to direct one man to examine all receptacles containing water, and oil them if they contain wrigglers.

7. The foreman himself will go through the house with the householder, and instruct that individual to remove clocks, sewing machines. freshly gilded picture frames, mirrors, candle sticks and like metallic bric-a-brac. Rooms in which there are pianos must be fumigated with pyrethrum.

Stores of tobacco, soap, flour, maccaroni, &c., are almost certain to be damaged, and should be removed before fumigation.

After overseeing the removal of articles likely to be injured, the foreman will direct the actual fumigation.

Two pounds of sulphur are to be burned to the thousand feet. Thus, a room 10 by 10 by 10 will require 2 lbs. A room 15 by 20 by 12 contains 3,600 cubic feet, and would require about 7 lbs. of sulphur. The length and breadth are to be obtained by stepping off. A long step of the average man is about three feet, and is near enough for practical purposes. The height of the room must be estimated by the eye. Ceilings range in height from 8 to 20 feet.

In order to estimate the quantity of sulphur used, the iron pot is to be weighed empty, and when three-fourths full of sulphur, the difference is the amount of sulphur to be used in a pot of that size.

8. All openings into rooms must be closed. Open flues or those not tightly closed, must be pasted over. Fire places must be filled up with old gunny sacks, and if not tightly closed by these means, must be pasted over. Crevices of doors or windows are to be closed by strips of paper pasted over them, as well as the key hole. This pasting is to be done from the inside of the room, the door for exit and egress to be left for the last, and is to be sealed from the outside. Where several rooms open into each other, it is not necessary to paste up the partition doors, which are to be left open and the rooms fumigated together.

Where door and window panels are of fine wood and close tightly, pasting may be omitted. Foreman must supervise the pasting, and see that the paste is not unnecessarily daubed on, or spilt on the floor. In using the paste, the brush is to be run across the crevices and the roll paper rapidly stuck on, an additional sweep of the brush over the paper is to be made, if the paper shows signs of sagging or falling off.

9. While pasting up of room is being completed, the sulphur pots are to be filled and set squarely in the centre of pans containing about an inch of water. The pans are to be set in centre of rooms, where there will be no danger of curtains or other drapery falling thereon, and thus starting a fire. The householder is advised to make a last-search for family pets, which often display a tendency to slip into the room.

The wardrobes and clothes closets are then to be opened. This is very important, and must never be neglected, because such receptacles are favourite hiding places for mosquitoes during the day time.

About one inch of alcohol is then put into the centre of the pot and the match applied, the door of exit to be closed and pasted from the outside.

10. In fumigating a house, the privy is not to be neglected ; it can be easily closed up by using paper freely. This is not done because of the sanitary conditions or odours of the closet, but because it is an enclosed space in which mosquitoes do and may take refuge. Likewise, if the stable or chicken house can be enclosed without too much labour, they are to be pasted and fumigated.

11. Pyrethrum powder is to be burned in parts of the house where sulphur would disturb the sick, or where there are pianos or other costly furniture. The room is to be similarly prepared in pasting up crevices, &c., with this difference, that the blinds of all windows but one are to be closed up, and on the floor in front of this window, which is to be left light, a white sheet is to be spread. When the smoke begins to get dense in the room, all insects will fly towards the light, and will hover about this window until they fall stupefied on the sheet.

In using pyrethrum, the proportion should be three pounds to the thousand cubic feet, with an exposure of three hours, and it is better to work on the principle of three pounds in three pots, or one pound to the pot, rather than use the three pounds in one pot. Water is to be used in pots, as for sulphur, and the same precautions used to prevent fire.

When the room fumigated with pyrethrum is opened up, the sheet is to be examined, the number of mosquitoes noted, and then the latter brushed into the still smoking pot. The floor of the room should also be swept rapidly, and the insects gathered up and thrown into the pot. A little alcohol may be carefully added from a cup to hasten the process. Alcohol must not be poured from the bottle, however, or accidents will happen.

In closing up a room for either sulphur or pyrethrum fumigation, the foreman should write on strip of paper closing the door the time that fumigation was started. He should also note it in his memorandum book, but this writing on the strip of paper will often prevent disputes with householders as to the time when the room should be opened.

12. The fumigation being well started, the foreman will take his gang and go to the next house, and at the expiration of two hours he should send back a man to open up a house being fumigated with sulphur.

A house fumigated by pyrethrum is to be opened up at the end of three hours, and two men had better be sent to do this, as the opening up of the room and sweeping up of insects must be done rapidly, since they are not always killed by the smoke, but only stupefied. No pots should be lighted after 4 p.m., in order that householders may not be kept out of their houses after nightfall. The men should be told off in rotation to open up the last house, and in this way a man will have to work overtime only one afternoon in five.

13. When the police are sent round to force entrance into premises, the Officer is to be the spokesman, and the foreman and his gang are not to interfere, unless the policeman is assailed and calls on them for assistance.

When a room has been broken open for fumigation by the police, a label to that effect is to be pasted over doors when the pots have been taken out. In addition, the door must be again securely nailed up, and a second label pasted over it stating that further fumigation of that particular room will not be necessary as long as this seal, which is pasted over the door in such a way that to open the door is to tear the paper, is unbroken. A similar label is to be used over doors of rooms which the householder states are not used. By this method, when a house is entered the second time for fumigation, the rooms which have unbroken seals on doors and windows need not be again fumigated.

Foremen must remember that they are invading the property of homes and disturbing the comforts of individuals. They must expect tongue lashings and other abuse, as part of their day's work for which they are being paid. They must keep their temper, try to make friends with these people, and *do the work* assigned them.

FIG. 11. Screening the Cisterns, New Orleans.
(From Report on Yellow Fever, British Honduras, 1905).

FIG. 12. A Properly Screened Cistern, New Orleans.

10. *Extension of Number of Days of Reinspection after Fumigation.*

This order was issued on August 30th, when no stone was being left unturned to grapple with the situation.

To Officers in Charge of Wards:

The instructions given you at the beginning of the present work included the reinspection of infected foci, from the 10th to the 25th day inclusive after the occurrence of first cases, in order that possible secondary cases might be discovered and properly treated. This reinspection is of such importance, that it has been decided to alter and extend it to include the 15th to the 30th day after the infecting case, and you are hereby instructed to alter the inspection time to the period stated.

You will acknowledge the receipt of this letter.

J. H. White.

11. *Fumigation Ordered before the Funeral in case of Death.*

To Officers in Charge of Wards and Others Concerned:

You are informed that the co-operation of the various funeral directors of the City has been requested in the matter of fumigating houses where Yellow Fever deaths have occurred, as soon as possible after the death and before the funeral, and they have been furnished with lists of various Headquarters, in order that prompt notification may be given the proper authorities.

You are directed to act on all such requests as soon as received, so that there will be as little delay in the funeral arrangements as possible.

12. The following forms were used and were regularly filled in:—

Fumigation Report.

.... 1905

Gang No. ....

Street.	No.	Rooms fumigated.	Rooms not fumigated.	Remarks for non-fumigation.
Totals..				..................Foreman.

INSPECTOR'S REPORT.

Ward No. ....Street No. ....

Number of persons living in premises ....

How many sick since April 1st? ....

What disease? ....

What Physician attended? ....

Is cistern oiled, and is it properly screened? If oiled, when was it oiled? ......

....

What is condition of privy vault? ....

Has it been oiled, and when? ....

Any wells, pits or holes on premises containing water? ....

Any barrels, tubs, flower pots, cans or other receptacles containing water?......

....

Are there any gutters containing stagnant water?..

What is general sanitary condition of premises? Give details, if not good ......

....

GENERAL REMARKS AND RECOMMENDATIONS.

....

....

(Under this head, if lot is empty, state whether there is any stagnant water on it.)

....

....

....

Name of Inspector ....

Date—New Orleans ....,

Seal placed on door of room by fumigator:

"If this seal is not broken the room will not require further fumigation."

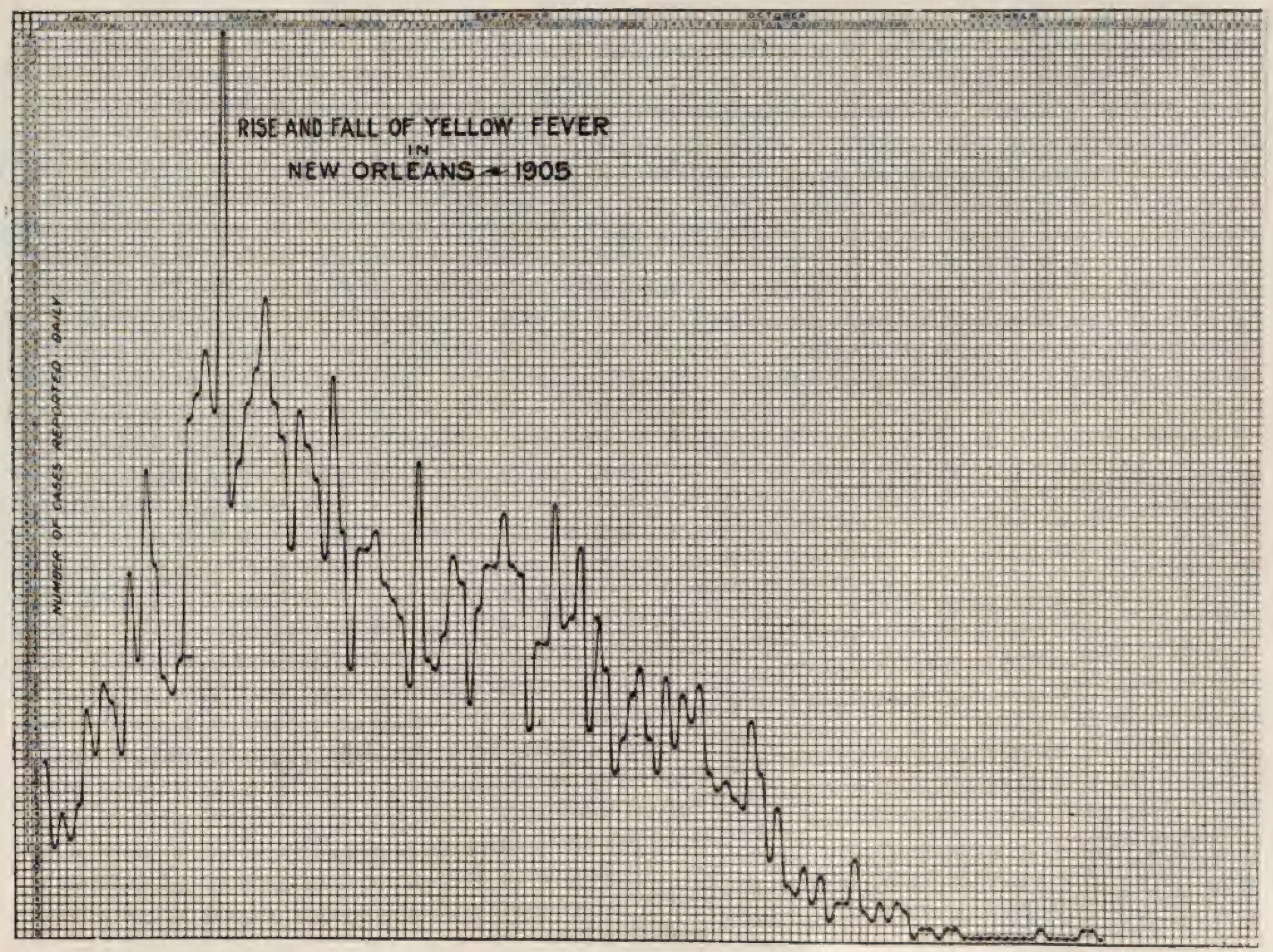
Warning attached to screen door of patient's room:

WARNING.

"This screen door must not be left open a minute for any reason whatever. If this screen door is found broken or propped open or the netting of the doors or windows torn, or cut, it will be sufficient cause to remove the patient to the Emergency Hospital."

PROGRESS OF THE FEVER.

Yellow Fever was officially declared on July 22nd, 1905, and on that date it is estimated that there were twenty cases. We have, however, every reason to believe that at that period there were far more cases, and that the disease had already spread over a very considerable area of the Italian quarter of the City. Examination of the Chart prepared by Dr. Quitman Kohnke shows that from July 22nd to August the 12th, on which date 105 cases were notified, the rise was exceedingly steep. It is probable that the estimate of 105 cases on the 12th of August, by which time the importance of early


RISE AND FALL OF YELLOW FEVER
IN
NEW ORLEANS — 1905
NUMBER OF CASES REPORTED DAILY

diagnosis had commenced to be realised, is more accurate than the estimated figure on the 22nd July, and that in reality the rise was more gradual from a much higher figure than 20 on the 22nd.

From the 12th July, when two very suspicious cases were privately reported, up to August the 4th, the local authorities dealt with the situation with increasing vigour. First, there were the measures undertaken by the State and Municipal Health Authorities. In spite of their efforts, however, the fever gained. Then on July the 22nd the campaign was taken up by the medical and citizens' Ward organisations working together with the local Health Authorities, and early notification and fumigation was universally advocated. On August 2nd, the screening of cisterns was made compulsory, and between 60,000 and 70,000 cisterns were screened in the course of a few days. This wise measure, however, would not produce an immediate effect in reducing the number of cases, for by this time the volume of infected mosquitoes in the houses would be very great; its effect would be seen later when the mosquitoes infected prior to the Ordinance having been killed by the repeated fumigations, there would be no fresh supplies of mosquitoes to take the place of those which were destroyed. As one would expect, therefore, the fever still increased, and on August the 4th it was decided to ask the Public Health and Marine Hospital Service to continue and perfect the campaign against the fever. On the 12th the fever reached its maximum point of 105, on the 17th the numbers were 74 and from this date onwards there was an absolutely steady fall into the first week in October, when the drop became more accentuated and two or three cases were reported on the average daily. It is clear that by August the 12th, the prophylactic measures, including early notification, isolation, fumigation, and cistern screening had begun to tell in no unmistakable manner, and that the Public Health and Marine Hospital Service Officers by most strenuous efforts and the exercise of the greatest vigilance and precision had made the occurrence of a subsequent recrudescence impossible. In three weeks time from the first official notification the fever was held absolutely under control, and was thenceforward week by week steadily driven back. There can be no doubt that the rigid control of the situation which commenced to be exercised after the 4th, was the great factor in preventing fresh outbreaks. The Chart is a splendid example of what

can be accomplished by modern prophylaxis. The campaign was started under most unfavourable conditions, for it is clear that there was a vast volume of infection in the most difficult district to deal with in New Orleans, containing for the most part non-immunes, who were adverse to medical advice and treatment. There did not even exist an hospital for infectious cases, and the climatic conditions were the worst possible, as the Season was unusually hot and close. The most striking evidence of the extraordinary difference of the results of the prophylactic measures adopted in this campaign as compared with previous epidemics in New Orleans is furnished by comparison with the number of cases on corresponding dates in the previous epidemics. Thus in the epidemic of 1898 two cases are reported on the 24th July; on August 12th there are 31 new cases; on the 14th the new cases were 134; steady increase takes place and on the 31st August the new cases are 234. Increase still takes place, and this, too, in spite of the adoption of all the methods then known to science, and which consisted in most rigid house quarantine; towards the end of September there is slight decrease, but in the first week in October as many as 305 new cases are reported on the 4th; the figures then slowly decrease to an average of about 60 new cases in the first week in November and after that the frost brings the fever to a close. The total number of cases were 13,817 with 3,984 deaths, as compared with 3,384 and 443 deaths in 1905. It would be impossible to obtain more striking figures of the thorough control which the organised medical forces had over the fever by the end of the first week in August, and solely by adopting one line of attack the destruction of the *Stegomyia fasciata* in the houses, prevention of their breeding in the water cisterns and early recognition and screening of the cases.

IV.—The Press and Educational Campaign.

From day to day the Press of New Orleans closely followed the progress of events. They were in constant touch with the Authorities and shared with the latter to the full the necessity of not alarming the public, but rather of reassuring them, and giving the fullest possible publicity to all sanitary measures issued by those in charge of the campaign. Thus in the commencement of the outbreak, there are no sensational headlines, indeed, the fact of the presence of

fever in New Orleans is only gathered by the headlines that " Quarantines are on," and that certain States and towns in the neighbourhood are becoming alarmed. Subsequently, they usually, each day, devoted a whole page or even more to an account of the previous day's progress of the fever, to the meetings of Health Officers, and other official meetings, to full accounts of lectures given in the evenings by properly authorised persons, and to descriptive articles upon the beneficial results which had followed Anti-Yellow Fever and anti-malarial measures in different parts of the world. At no time does an antagonistic note appear to have been struck. The Press, reflecting the feelings of the community, were intensely loyal, put the fullest confidence in those who were charged with the conduct of the campaign, and avoided taking any premature steps which might have interfered with the satisfactory progress of official work. The result was that they always appeared to me to enjoy the full confidence of the Authorities. Together with the Citizens' Ward Organisation they took a leading share in stimulating all classes of society to a sense of their duty in the emergency, and of impressing upon the public the necessity of going about their work cheerfully and with complete confidence in their ultimate success. At no time did New Orleans ever appear depressed, indeed, the motto, ascribed to the Rev. Dr. Warner which was hung up everywhere in hotels and public places, " Wear a smile on your face and a flower in your button-hole," was acted upon. Another result of the wide publicity given by the Press to the nature of Yellow Fever and of its relationship to *Stegomyia fasciata*, was that when I arrived in New Orleans in August, doubters of the true way in which Yellow Fever was carried would have fared very ill. Everyone felt that it was not a time for two opinions, and that there was only one safe line of action—implicit belief in the teaching of Reed, Carroll, Agramonte and Lazear. In this respect the campaign was a triumph for medical science. In a few days with exceedingly little opposition, sixty to seventy thousand cisterns had been screened in order to prevent the breeding of the *Stegomyia fasciata*. Mosquito nets became more than ever the rule, and the richer inhabitants in the suburbs went to considerable expense in wire screening the verandahs and rooms of very many of their houses, and a badge worn in the button-hole with the image of the Stegomyia and the words " Have you screened your cisterns? I have mine," was

very commonly worn by the younger members of the community. When it is recollected that New Orleans possesses very diverse elements, that there are newspapers in English and in French, that there is a very large Italian population, and that there are corresponding religious differences, it is a very striking fact that literally in a few days there should have been complete unanimity and enthusiasm as regards the plan of campaign. I reproduce some of the headings and other data which appeared in one of the leading daily journals (" The Daily Picayune "). On July 22nd, that is five days after the official announcement of Yellow Fever is made, the following headlines appeared, which sufficiently indicate that the campaign had started on right lines.

CLEAN-UP CLUBS FORMING IN EVERY CITY SECTION.
ALL WITH THE PATRIOTIC PURPOSE OF AIDING AUTHORITIES IN CONQUERING DISEASE.
AND PROVING TO THE WORLD THAT SCIENCE HAS REMOVED NECESSITY FOR FEAR.
EDUCATIONAL CAMPAIGN ON THE DANGEROUS MOSQUITO BEING EXPOSED AND WELL FOUGHT.
14TH WARD MAKES WHOLESALE CONTRACT FOR CISTERN SCREENS AT A DOLLAR EACH.

On August the 3rd the newspapers gave great prominence to the importance of re-oiling the cisterns owing to the fact that a heavy rain-storm had washed the oil out. The following is an example:—

Oil again and keep on oiling. Until screens are in place and pest exterminated. Volunteer Forces urged to maintain the ground gained. Inspectors will make sure of campaign's efficiency. A noteworthy series of educational mass meetings to be inaugurated to-night.

Further on again the following occurs:—

Oil again. Keep a weather eye on the rain barrel. After a second oiling, then screen before another overflow washes away the good effect. Where re-oiling of cisterns did not start yesterday, it will be begun to-day. This was the advice sent out from Dr. Beverley Warner's headquarters of the Citizens' Volunteer Ward Organisations. The day's energy in fact was devoted to re-oiling. At least three-fifths of the cisterns of the whole City had been gotten in good shape when the rain and thunder-storm of Tuesday evening caused an overflow of cisterns and a loss of oil. The barrels of liquid that had been dumped into cisterns in all sorts of fashion were flowing over the town in the open gutters.

"The one message that I wish to send out from headquarters to-day," said Dr. Warner, "is that it is absolutely necessary to oil cisterns again. All of them did not overflow, but two-thirds did, and the oil has been lost. Then if we can get them screened before another overflow, we will be all right. Oil again. I hope the papers will preach that to-morrow morning. In some of the wards where screening was in progress the crews were taken off the screening and put to oiling again."

On the same date the following announcement is also made :—

EITHER MOSQUITOES OR MEN MUST RULE.
THE QUESTION PLAINLY PUT BEFORE THE PEOPLE HERE.
IN THE FIRST OF GENERAL EDUCATIONAL MASS MEETINGS.
LEADERS IN SCIENCE PRESENTING TRUTH OF MOSQUITO THEORY.
AND URGING THE PEOPLE TO STAMP OUT THE PEST AND
REDEEM THE CITY FOR EVER.

The first gun of the educational warfare against the stegomyia was fired last night, when the inaugural mass meeting of the respective wards was called to order in the First Ward by the Hon. C. Taylor Gauche. It is proposed to hold public meetings in every ward of the City, and through speakers, well versed in the elucidation of the questions of vital importance to the health and prosperity of New Orleans, to thoroughly and accurately inform the people and to teach them with regard to the now accepted fact that the stegomyia mosquito is the conveyor of Yellow Fever, and that the extinction of the pestiferous insect now will mean absolute freedom from Yellow Fever for all time to come.

The following day practical suggestions were also published :—

VALUABLE SUGGESTIONS (from a Local Medical Man).

Don't put any more gangs to work than you have trustworthy foremen for; the oiling and screening must be as thorough, complete and effective as the preparations for an aseptic operation.

Get the ladies of your ward to make you numbers of carpenters' aprons. You will need them when you get to screening.

Get the ladies to provide bits of pasteboard or woollen stuff about one inch square to run your screening tacks through. They hold the cheesecloth much better.

Don't economize on tacks. The mosquito can creep through very small holes.

Screening gangs need plenty of hammers and shears. Better lay in a full supply.

Keep accurate account of premises to which you are denied entrance, of empty houses into which you cannot get, and of those where the tenant makes himself responsible for the oiling and screening. These will provide the breaches through which the enemy will find entrance, if they are not stopped.

Inspect and re-inspect all work done, by the most intelligent and conscientious inspectors you can find.

All inlet pipes of 10 feet long or over should be screened and lower ends of all outlet pipes covered with cheesecloth securely tacked or tied.

The end of outlet pipes may be immersed in a pail of water, which can be kept oiled by the householder.

All householders should be asked to sweep standing water out of the gutters. Where they cannot attend to it, screening gangs should look to it.

On the date appointed for the cleaning of the City the announcement in the Press is :—

Greatest cleaning the City has ever enjoined. Thousands of men and carts to be engaged in to-day's battle against dirt. And City Administration will seek to make permanent the improvement which the forces expect to secure.

The result of the cleaning was, indeed, manifest, the accumulations of years was got rid of and the City made far more wholesome. Some 800 extra labourers were employed and 250 carts. It was pointed out that this cleaning whilst it did not necessarily affect the

Stegomyia or the progress of the Yellow Fever, was, nevertheless, most advisable upon general sanitary grounds.

Upon August the 6th is published the results of the first week's working of the Citizens' Volunteer Ward Organisation. It is a sample of the work done at the stage when the Public Health and Marine Hospital Service had not taken over the campaign.

A summary of the work done in the several wards by volunteer committees for the first week during which Dr. Beverley Warner has been in command as General Superintendent, was compiled in his office yesterday. It is not perfect owing to the extreme difficulty of getting prompt responses from the ward executives who are so busily engaged in the work. It will give the residents of New Orleans an idea of what has been done so far. The summary follows :—

First Ward.—Number of men employed, 28 ; cisterns oiled, 3,216 ; screened, 310 ; cesspools treated, 2,926.

Second Ward.—Men employed, 96 ; cisterns oiled, 3,975 ; screened, 469 ; cesspools treated, 2,611.

Third Ward.—Cisterns oiled, 9,000 ; screened, 9,000.

Fourth Ward.—Men employed, 25 ; cisterns oiled, 3,200 ; screened, 1,000 ; cesspools treated, 3,100.

Fifth Ward.—Cisterns oiled, 1,480 ; screened, 86.

Sixth Ward.—Men employed, 16 ; cisterns oiled, 2,384 ; screened, 67 ; cesspools, 2,033.

Seventh Ward.—Men employed, 115 ; cisterns oiled, 3,200 ; screened, 500 ; cesspools treated, 2,500.

Eighth Ward.—Cisterns oiled, 603 : screened, 31 ; cesspools treated, 183.

Ninth Ward.—Men employed, 214 ; cisterns oiled, 1,563 ; screened, 197 ; cesspools, 233.

Tenth Ward.—Men employed, 25 ; cisterns oiled, 1,114 ; cisterns screened, 1,114 ; cesspools treated, 1,114. Tenth Ward (Middle Section) : Men employed, 77 ; entirely oiled, and 37 squares screened.

Eleventh Ward.—Entire ward oiled and one-third screened. Cesspools treated, entire ward.

Twelfth Ward.—Cisterns oiled, 2,596 ; screened, 934 ; cesspools treated, 2,620.

Thirteenth Ward.—Entirely oiled.

Fourteenth Ward.—Cisterns and cesspools entirely oiled ; screened, 1,405.

Fifteenth Ward.—Men employed, 12 ; cisterns oiled, 1,609 ; screened, 200 ; cesspools treated, 1,609.

Sixteenth and Seventeenth Wards.—Men employed, 18 ; cisterns oiled, 1,932 ; screened, 98 ; cesspools treated, 757.

There have been 660 stagnant water pools covered.

Speaking of this first weekly report, Dr. Warner said :—

" It is a revelation of patriotism and loyalty to the City of which we should all be proud. Anyone who has ever been engaged on such work on so large a scale is aware of the infinite number of hindrances and embarrassments that are sure to arise. How these have been met and overcome by the ward officers I am in a position to know perhaps better than anyone else ; how faithful the volunteers have served amid inevitable criticism and the occasional indifference on the part of those for whom their services are rendered we also know. By the middle of this week the work of oiling and screening will probably be entirely accomplished. This is but the beginning of the fight."

On August 17th the Press make the announcement that Sunday, August 20th, is to be made a general fumigation day and publish the following statement:—

It is incumbent on every good citizen to use the means God has placed in his or her hands to prevent Yellow Fever from becoming epidemic and to lessen the future chance of further infection.

It is an absolutely established fact that the disease is communicated from person to person by the mosquito alone.

The screening and oiling that has been done will destroy the chance of new broods of mosquitoes hatching. The mosquitoes that were hatched before the screening and oiling were done, are still about the City in vast numbers, and are, in the present crisis, liable to become as dangerous as so many rattlesnakes.

To get rid of these mosquitoes requires fumigation by sulphur fumes. This fumigation, to be effective, must be done by a preconcerted, organized movement by all the citizens and householders of this City, on a given day and at a given time.

If every room and inclosed space within the limits of New Orleans is fumigated on the same day and at the same hour with sulphur fumes, and for two full hours, the mosquitoes will be destroyed, and the medium of Yellow Fever infection removed, so that within a week from the date of this general fumigation of the whole City the table of new cases published daily will fall to a small percentage of what it is at present.

Therefore we appeal to every householder, every boarding or lodging house keeper, every hotel keeper, every merchant and manufacturer, every person occupying any inclosed premises of any nature, whether it be a stable or a room in an office building, to see that

NEXT SUNDAY, AUGUST 20TH, AT 10 O'CLOCK A.M.,

any and every room or enclosed space under their control is fumigated for at least two hours with sulphur fumes, in accordance with the directions of the Marine Hospital Service, which will be published.

BEVERLEY WARNER,
General Superintendent.

On August 25th, after a month's work, the Press make the following encouraging announcement:—

Last night closed the first month's struggle of the City of New Orleans against Yellow Fever. Probably no city in America has ever made such a valiant fight against disease as has been made by the citizens of this City and State, who have contributed their money and their labor to stamp out the mosquito pest and stop the spread of fever.

An army of men has been enlisted in this sanitary war. A fund of a quarter of a million of dollars has been raised and is being expended, with probably as much again having been contributed to the fight in one way or another.

During the first month business was practically suspended for one day, and everyone devoted their energies to cleansing and scrubbing the City.

Thousands of men have worked in the streets, and hundreds of carts have been employed carting away the scrubbings.

To-day the whole City will fumigate. Sulphur has been secured by the carload, probably about twenty cars, and it has been distributed among the wards for free distribution among those unable to buy, and at 10 o'clock this morning every house is expected to be fumigated with sulphur, thereby killing mosquitoes that may be hiding in dark corners and crevices. Everyone is again urged to fumigate. By everyone smoking them out at the same time it does not leave places of refuge in which the stegomyia can seek and find a safe haven. If everyone follows instructions to-day there will be a widespread slaughter of the *Stegomyia fasciata*, and to that end the spread of fever largely checked.

To-morrow at 10.30, the churches have arranged for an hour of prayer, when all denominations will meet at the Y.M.C.A. Hall and ask God's blessing on the heroic work of the men and women of this fair City. All ministers, irrespective of their creeds and denominations, are urged to join in this union prayer service and to ask their congregations to attend.

Last night marked the close of the third week of the work of Dr. Beverley Warner and his volunteer department. When asked for a summary of the situation up to date, Dr. Warner said :—

"We are beginning to see very clearly the effects of the work accomplished both by the Marine Hospital Service and by the Volunteer Organizations. The fever is not as rampant as we would have expected from the first reports at the end of July. This is owing, first, to the preparatory work done by the City; second, and of most importance, of course, to the careful and faithful efforts of the Marine Hospital Service, under the direction of Dr. White.

"The public is already reassured, and, to judge from the evidence of the mass meetings are not only interested in the discussions, but are impressed more and more with the mosquito theory. The most important event of the week was the adding of Dr. Juan Guiteras to the ranks of the volunteer speakers. This will give the people in all sections of the City an opportunity of seeing and hearing Dr. Guiteras. It is the universal verdict that he carries conviction of the truths he advocates.

"We close the week with a feeling of enlarged hope and greater courage."

Garlick, the billposter, has done a unique thing, and one that appeals to Dr. Warner as a splendid contribution to the great cause, and that is the printing of several thousand large posters, in red ink, telling in a word of the absolute proof of the mosquito theory, and urging the people to fumigate and carry out the mandates of the Federal authorities. These posters were sent all over the City and placed on the Garlick boards free of charge.

IN A NUT SHELL

WE ALL KNOW THE DANGER OF

YELLOW FEVER

but we become EARNEST ONLY
after it claims our own blood

INFECTION BY MOSQUITOES

IS NO LONGER A THEORY
BUT A PROVEN FACT

GET RID OF THE MOSQUITO

BY BURNING

SULPHUR FOR FUMIGATION

UNDER THE DIRECTION OF THE

MARINE HOSPITAL SERVICE

START IN ON

SUNDAY AT 10 A. M.

**AND KEEP AT IT UNTIL NOON
OR LATER**

Copy of Poster issued.

A sulphur depôt was established for the Fourteenth Ward at No. 6,053, Constance Street, yesterday, with J. J. Beahr in charge. This is for the aid of the poor in that ward.

Three more cars of sulphur were received yesterday and reported to Dr. Warner for the use of the wards in distributing to the poor.

Two important meetings have been scheduled for to-night. The one at the First Baptist Church, on Magazine, near Washington Avenue, will be addressed by Dr. J. H. White, Dr. Pothier, Dr. Warner, Rev. C. V. Edwards, and others.

An important meeting has also been billed for the coloured church on Austerlitz Street, between Magazine and Constance, to-night at 8 o'clock, which will be addressed by Dr. Kohnke and others.

Monday night will witness three large mass meetings. Touro Synagogue will be one of them, where Drs. Guiteras, Bloom, Matas, Fenner and Warner will speak. Time, 8 o'clock.

Y.M.C.A. Hall, 8 p.m., addresses by Drs. Guiteras, Sexton, Kohnke and others.

Presbyterian Church, Euterpe and South Franklin Streets, addresses by Drs. Smith and Metz and Prof. Beyer. Time, 8 o'clock.

On Tuesday night, Bishop Davis Sessums and Dr. Kohnke will be leading speakers at a big coloured mass meeting in the First M.E. Church, corner First and Dryades Streets.

These concluding paragraphs of the month's work give a very good idea of the extent of the educational campaign. Lectures were fixed for almost every evening during which the fever lasted, and by these means all classes of the community were reached. Dr. Warner who, as we have seen, as superintendent of the Volunteer Ward Organisation, took the lead in organising the educational campaign, was also enthusiastically supported in this movement by the Home and Education Department of the Woman's League. Under the chairmanship of Mrs. W. J. Behan a very large number of popular lectures were organised both indoors and in the public Park. Indeed, they appear to have commenced the educational movement before the outbreak of the Fever. They also did not confine themselves to lectures, but by forming Ward Clubs and appointing visitors they assisted in urging the necessity upon each householder of oiling and screening.

V.—The Financial Organisation.

A campaign of the magnitude of that which took place in New Orleans in 1905 could not have been successfully conducted unless there had been liberal financial support. The necessary large sums of money to undertake the prophylactic measures were, with very great promptness and generosity, subscribed by all classes of citizens. I will conclude this description of the 1905 Yellow Fever epidemic with the following statement kindly furnished to me by Mr. Janvier, Chairman of the Yellow Fever Fund, of how the funds were raised.

Citizens' Yellow Fever Fund Committee.

New Orleans, *September* 15, 1905.

On Friday, July 22nd, 1905, the Mayor of the City of New Orleans invited the State and City Health Officers and a number of citizens prominent in business and professional life, to meet in his office for the purpose of conferring upon the fever situation. This conference was held on Saturday, July 23rd, and at this conference a Finance Committee was named by the Mayor and charged with the duty of gathering the funds requisite to carry on a fight against the fever then prevalent. This Committee set to work without delay soliciting contributions. The Committee began operations with a fund of $20,000.00 which had been placed in our hands by the associated banks of the City, and within a few days contributions began to come in generally and generously. When it was realized that the local authorities—State and Municipal—were unable to satisfactorily cope with the situation, and an appeal was made to the Governor of the State to request the Federal or General Government to take charge, the Committee had accumulated about $60,000.00. On Sunday morning, Aug. 7th, Dr. J. H. White, who had been sent to New Orleans by the U.S. Public Health and Marine Hospital Service, received tne following telegram from Dr. Wyman, the head of that branch of the general Government :—

"Surgeon White, St. Charles Hotel, New Orleans, La. In answer to telegram of Aug. 4th you state that the citizens have raised a large fund and promise to raise more, though amount is not definitely stated.

"It is very important that this matter should be settled before definite action can be taken Your estimate in second telegram of Aug. 4th, makes total expenses for eradication at $1,500.00 to $2,000.00 per day.

"You do not state whether this amount is expected of the Service. Bureau estimate for forty officers, mentioned by you as being required, would be about $500.00 per day. The epidemic fund will not stand or permit of $1,500.00 to $2,000.00 per day. This is absolute. Bureau would be willing to give you all the medical officers necessary, but the labor and materials should be furnished by the citizens, as has been done heretofore.

"Wire promptly whether this arrangement can be effected, that I may give my opinion to the President.

"Attention should be called to the fact that the Government is now maintaining detention camps in the interest of New Orleans, and expense must be met for inter-state measures. Rush answer. Wyman."

Upon receipt of this telegram Dr. White requested an immediate conference with the Mayor of the City and the Citizens' Finance Committee. As a result of this conference, the following telegrams were dispatched to the President of the United States and Surgeon-General Wyman :—

"Surgeon-General Wyman, Washington, D.C. The citizens of New Orleans pledge themselves to secure and furnish all the funds necessary to pay the expenses which your service may incur for labor and materials in dealing with situation here. This in accordance with Dr. White's telegram to you. Martin Behrman (Mayor), Charles Janvier, Gus. Lehmann, Sr., Wm. Adler, W. G. Tebault, Citizens' Committee."

This telegram was sent to President Roosevelt, at Oyster Bay :-

"The President, Oyster Bay, New York. We heartily thank you for your prompt and generous action which, though expected, was none the less most gratifying. We pledge ourselves to do our share, and have wired Surgeon-General Wyman that we would secure and furnish all the funds the service may require. Martin Behrman (Mayor), Charles Janvier, Gus. Lehmann, Sr., Wm. Adler, W. G. Tebault, Citizens' Committee."

These telegrams were followed by the following from Dr. White to Surgeon-General Wyman :—

"New Orleans, Aug. 6th. Citizens' conference wires to-day that if you furnish the officers they will furnish $3,000.00 per day, if needed. They begin with sixty-odd thousand in hand and can easily raise the rest. They give us authority to discharge and employ and in no way tie our hands. No offer could be more frank, and I unreservedly recommend that we accept the trust at the earliest possible moment, because time is extremely valuable. J. H. White."

"New Orleans, Aug. 6th. Funds promised for work by bankers, merchants and Mayor, will be disbursed by Colonel Janvier and rolls kept under his orders. Mayor verbally promises in open conference to supplement if need be, and to give full police authority. The Committee's telegram to you, signed by the Mayor and several wealthy men, sufficient written agreement. City ordinances, including one recently passed, are sufficient. J. H. White."

The Finance Committee prepared and had published in the newspapers the next morning the following appeal to the people of the City :—

"New Orleans, La., Aug. 6th, 1905. To the Citizens of New Orleans : We respectfully ask your earnest attention to the telegram from Surgeon-General Wyman, of the United States Public Health and Marine Hospital Service, in which are stated the conditions under which the Service will assume control of the fever situation here. As immediate action was imperative, Mayor Behrman agreed at once to these conditions, and in your behalf we gave the pledge that you would contribute the funds which might be required in the prosecution of the fight. The undersigned Committee has now in hand about $70,000.00. A very much larger sum than this will be needed, and we should be able in a few days to place at the command of the Federal authorities at least $250,000.00. The State and City can be counted on to do their duty, but the individual citizen must do his. The people of New Orleans, in times of emergency, have never faltered or failed and we appeal to you to indorse and redeem the pledge made by us in your behalf. Not one dollar of the funds contributed will be spent except under the direction of the United States Public Health and Marine Hospital Service. Contributions will be received by Charles Janvier, Chairman, at the Canal Bank and Trust Co. Charles Janvier (Chairman), Gus. Lehmann, Sr., Wm. Adler, W. G. Tebault, Finance Committee, Yellow Fever Fund."

The responses to this appeal were prompt and liberal and in a few days the fund had increased to $100,000.00. The Governor of the State had promised that when called upon the State would help, and on the 7th of August I wired His Excellency as follows :—

"To Governor N. C. Blanchard, Baton Rouge, La. We appeal to the State of Louisiana for financial aid in the present emergency. The citizens of New Orleans have given their pledge to the United States Government that the funds required by the United States Public Health and Marine Hospital Service would be furnished and

have given the assurance that the State and City could be counted on to do their share. The people are responding generously to the appeal. The emergency warrants you in taking in the present instance the same steps to furnish the aid we ask as were taken by your predecessors in similar emergencies, notably the drought and high water emergencies and the Yellow Fever epidemic of 1897. Charles Janvier, Chairman, Citizens' Yellow Fever Committee."

The Fiscal Agents of the State at the same time wired the Governor that they stood ready to advance to the State at the rate of two per cent. per annum the money which might be required, upon the assurance from him that the Legislature of the State would include such advance in the Appropriation Bill at the next session of the General Assembly. Promptly upon receipt of my wire, the Governor replied as follows:—

"The State should help New Orleans financially and every other way in this emergency, and she will. Am getting into communication with legislators. Will make the loan as soon as I have heard from a sufficient number. I think it will be all right. Go ahead. N. C. Blanchard, Governor."

In a few days the Governor, in response to his telegraphic inquiries, received pledges from more than a majority of the members of the General Assembly that they would at the next session vote for the appropriation of $100,000.00, for the purpose of helping the people of New Orleans in their fight against the fever, and the Governor informed me at once that the State was prepared to help to that extent and would increase the amount if the necessity for so doing should arise. (It is interesting to note at this point that the Governor finally heard from all the members of the General Assembly and there was not one single dissenting voice.) In the meanwhile, the Mayor of the City had called the City Council in conference and in due course the Council passed by unanimous vote an ordinance, on Aug. 17th, 1905, authorizing the Mayor to effect a loan with the City's Fiscal Agents and place at the disposal of the Citizens' Yellow Fever Fund Committee the sum of $50,000.00.

While the sum of $250,000.00, which the Committee in its appeal stated would be necessary, had been thus secured, the Committee did not cease their efforts to still further augment the fund, and at the present writing the Citizens' Yellow Fever Fund amounts to over $137,000.00.

The Governor has been obliged to divert $20,000.00 of the State fund to help other sections of the State, leaving $80,000.00 still at our command from the State.

The amount of money, therefore, that we have raised up to the present time is over $267,000.00, which should be sufficient to pay all the expenses of the campaign, and leave a handsome balance in our hands. We desire when this fight is over to construct, equip and maintain an Isolation Hospital of the very finest character, for the care and treatment of contagious and infectious diseases, and to that great purpose will be applied whatever sum may be left in our hands at the conclusion of the present fight.

I trust that the foregoing gives you all the information you desire in connection with the financial side of our present struggle.

Yours respectfully,

CHARLES JANVIER,

Chairman, Citizens' Yellow Fever Fund Committee.

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1906

RAPPORT SUR L'EXPÉDITION AU CONGO

1903-5

ECOLE DE MÉDICINE TROPICALE DE LIVERPOOL—MÉMOIRE XX

RAPPORT

SUR

L'EXPÉDITION AU CONGO

1903-5

PAR

J. EVERETT DUTTON, M.B. VICT.
(DE SON VIVANT)
WALTER MYERS FELLOW À L'UNIVERSITÉ, LIVERPOOL

ET

JOHN L. TODD, B.A., M.D. McGILL
DIRECTEUR DES LABORATOIRES DE RECHERCHES À RUNCORN

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CONTENTS

PROPHYLAXIE DE LA MALARIA

PREFACE

Aux colons de l'Etat Indépendant du Congo je dédie cette brochure. Qu'il soit bien entendu qu'elle n'a pas la prétention de donner un exposé complet du sujet. Elle poursuit un double but ; d'abord de permettre au profane de se faire une idée exacte de la facilité avec laquelle l'infection malarienne peut être évitée dans la plupart des cas, ensuite d'indiquer à grands traits aux médecins de l'Etat Indépendant du Congo les mesures à prendre pour sauvegarder la santé de ceux qui sont confiés à leurs soins.

Afin de réaliser le premier desideratum nous nous sommes efforcés de nous exprimer en une langue aussi simple que possible ; quant au second point de vue, ce rapport ne fait qu'indiquer certaines defectuosités existantes et les remèdes à y apporter. On ne saurait trop nettement déclarer que nos indications, quoique correctes en elles-mêmes, devront être corroborées par le labeur constant d'officiers sanitaires au courant des méthodes modernes de prophylaxie et assistés par un corps bien stylé d'inspecteurs et d'ouvriers indigènes.

Il faut remanier l'organisation du service médical ; voilà le premier pas à faire pour assurer la santé publique dans l'Etat Indépendant. Un complément de connaisances doit être exigé des officiers sanitaires et, pour tirer de leur activité tout le bénéfice désirable, leurs relations avec le pouvoir administratif doivent être modifiées dans le sens indiqué dans le texte.

J'ai inscrit en tête de ce rapport le nom de mon compagne de travail le regretté Dr. J. E. Dutton. Celui-ci a collaboré activement en effet aux observations qui y sont consignées mais moi seul je suis responsable de l'esprit dans lequel il a été redigé. J'espère que ceux qui n'approuveront pas nos conclusions voudront bien se rappeler dans leurs critiques, de quelle façon il a été fait usage du nom du Dr. Dutton.

Les plans des différents postes qui accompagnent ce travail ne sont pas absolument exacts et ne sont qu'approximativement reduits à l'échelle.

Un certain nombre d'expressions impropres choqueront sans doute le lecteur. Qu'il me soit permis de lui rappeler que ce rapport est écrit en une langue qui m'est étrangère.

J. L. T.

LABORATOIRES DE RECHERCHES À RUNCORN,
Juin 1906.

SOMMAIRE

RAPPORT

SUR LA

PROPHYLAXIE DE LA MALARIA

DANS LES

PRINCIPAUX POSTES DE L'ÉTAT INDÉPENDANT DU CONGO

5ième "Progress Report" de l'Expédition de l'Ecole de Médecine Tropicale de Liverpool au Congo, 1903-1905

PAR

J. EVERETT DUTTON, M.B. VICT.

(DE SON VIVANT)

(WALTER MYERS FELLOW, À L'UNIVERSITÉ, LIVERPOOL)

ET

JOHN L. TODD, B.A., M.D. MCGILL

(DIRECTEUR DES LABORATOIRES DE RECHERCHES À RUNCORN)

I. Remarques Préliminaires.

Ross montrait pour la première fois en 1898 que la malaria était une maladie infectieuse et qu'elle se transmettait d'homme à homme par l'intermédiaire de moustiques, les *Anophelinæ*. Depuis lors le fait a été amplement confirmé par les travaux de nombreux savants tant en Italie qu'en Amérique, en France, en Allemagne et ailleurs. Non seulement c'est un moustique qui transmet la maladie, mais **elle ne peut être transmise que par cet insecte et le moustique lui-même ne peut être contaminé que par un être humain.**

Aucun observateur compétent n'a produit de faits qui ne fussent complètement expliqués, et cela d'une manière tout à fait satisfaisante, par la " théorie des moustiques," telle que nous venons de l'exposer.

Quelque temps avant la découverte du rapport qui existe entre la malaria et les *Anophelinæ*, on avait prouvé que l'éléphantiasis, qui est si fréquente chez les indigènes de certaines régions tropicales, était causée par un petit ver appelé *Filaria*. On montra tout d'abord, que ce parasite passait une partie de sa vie dans le corps d'un genre de moustique, connu sous le nom de *Culex*, et qu'un grand nombre de moustiques appartenant à ce genre, ainsi que certains *Anophelinæ*,

étaient susceptibles de transmettre la filaria à l'homme lorsqu'ils en sucent le sang.

On a également prouvé qu'un autre moustique, le *Stegomyia fasciata*, pouvait communiquer la fièvre jaune, d'un individu atteint à un individu sain. Il n'est pas improbable, que d'autres maladies encore puissent être transmises par la morsure de ces insectes.

Nous savons donc que trois des plus importantes maladies des tropiques, trois de celles qui font les plus grands ravages, sont transmises par les moustiques.

Il est peut-être superflu d'attirer l'attention sur les pertes énormes qu'entraîne la présence de pareils fléaux, tant à cause de la mortalité qui en résulte, que des interruptions apportées au commerce et des dépenses en argent nécessitées par les travaux de désinfection et de mise en quarantaine.

Il n'est pas nécessaire non plus d'insister sur les entraves qu'apporte ce mauvais état sanitaire à la colonisation et à la mise en valeur des régions tropicales, et en particulier de l'Afrique.

L'insalubrité tient, sans doute en partie, au climat qui est énervant pour les blancs ; mais les " maladies tropicales," comme on les appelle, ont contribué beaucoup plus au mauvais renom d'un grand nombre de colonies de la région des tropiques.

Nous avons attiré l'attention du lecteur sur le fait que trois des principales maladies des climats chauds étaient transmises, d'homme à homme, par les moustiques. C'est donc la destruction de ces insectes qui devra en premier lieu attirer l'attention des gouvernements locaux, quand ils s'occuperont de l'amélioration, au point de vue sanitaire, des villes et des agglomérations de la zone des tropiques. Il faut qu'on se rende bien compte dès l'abord que, dans les villes, **tous les moustiques sont dangereux et que leur destruction absolue est un idéal à atteindre.**

Des travaux et des observations de date récente ont montré que les nègres souffrent dans une large mesure de deux maladies tropicales importantes, auxquelles on les avait souvent crus réfractaires, le paludisme et la fièvre jaune. Il est vrai que généralement ils ne sont pas si sérieusement atteints que les Européens. Cependant les rapports qui ont été écrits sur les nombreuses épidémies de fièvre jaune, établissent que des indigènes en sont morts. Et c'est un fait connu que le chiffre de la mortalité infantile en Afrique a toujours été très

élevè et qu'il est dû en grande partie à la malaria. Ce qui montre bien que les travaux d'amélioration sanitaire, entrepris en se basant sur le principe de la destruction des moustiques, ne profiteront pas seulement à la population blanche, c'est-à-dire à une petite partie de la population des tropiques, mais bien à cette population tout entière. Et c'est, à n'en pas douter, une tâche **qui incombe à un Gouvernement responsable du bien-être de ses administrés, que de prendre des mesures dans ce sens.**

Ceux qui ont le plus d'expérience dans ces questions de prophylaxie pensent qu'il est possible, étant donnée une localité favorable, de réduire le nombre des moustiques dans de telles proportions, que non seulement le nombre des cas de maladies colportées par ces insectes sera réduit au minimum, mais que les autorités chargées de veiller à la salubrité publique n'auront pas lieu d'éprouver d'inquiétudes sérieuses, à la pensée que le fléau pourrait s'introduire du dehors.

Nous donnons les chiffres suivants comme pouvant montrer les bienfaits qui résultent de la destruction méthodique et consciencieuse des moustiques.

Ismailia est une ville d'environ 6,000 âmes, composée principalement d'employés de la compagnie du Canal de Suez. Les mesures prophylactiques contre la malaria, basées sur le principe de la destruction des moustiques, furent prises pour la première fois pendant l'automne de 1902. Le nombre annuel des cas de malaria à Ismailia était monté, de 300 qu'il était environ en 1877, à 2,250 en 1900. Voici les chiffres pour les années qui ont suivi :—

			Début de la Campagne.			
Années	1900	1901	1902	1903	1904	1905
Nombre de cas	2,250	1,900	1,548	214	90	37

Il est à remarquer que presque tous les cas, en 1904, étaient dûs à des rechutes et, qu'en 1905, ils l'étaient tous. En 1905 le Dr. A. Pressat écrivait : " La malaria a disparu à Ismailia."

Dans les années 1901 et 1902 on a pris des mesures semblables à Klang et à Port Swettenham, dans les États confédérés de Malaisie. Les chiffres suivants montrent qu'une amélioration permanente en est résultée :—

		Début de la Campagne.			
Années	1901	1902	1903	1904	1905
Nombre de cas de malaria admis à l'hôpital	610	199	69	32	23

A la Havane, la campagne entreprise contre les moustique a été commencée en 1901. Le tableau suivant, qui en montre les résultats, est suffisamment éloquent :—

							Début de la Campagne.				
Années....	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905
Décès: Fièvre jaune	552	1,385	745	128	122	302	5	0	0	0	22
Décès: Malaria	206	450	811	1,907	909	325	151	77	51	44	32

La nouvelle méthode de prophylaxie, en diminuant les chances de maladie, est très favorable à l'extension et au développement des grandes enterprises dans les climats tropicaux. Citons encore la construction du Canal de Panama. En Octobre, 1884, du temps de la compagnie française, il y avait 21 décès et 84 cas de fièvre jaune sur 2,706 individus susceptibles de la contracter et sur un total de 19,243 employés. En Octobre, 1905, avec les Américains, alors que les méthodes modernes étaient appliquées, sur 4,000 individus susceptibles de la contracter et un total de 22,000 employés, il n'y avait pas de décès et un cas seulement de fièvre jaune.

Les succès obtenus dans ces différents endroits se répètent sans cesse ailleurs.

Dans notre rapport nous exposerons d'abord à grands traits la vie, les habitudes et les méthodes de destruction des moustiques. Nous décrirons ensuite d'autres méthodes de prophylaxie contre la malaria. Dans la section VII nous traitons de la nécessité d'une législation bien définie sur la question des moustiques, et de la façon dont il faut s'y prendre pour assurer la destruction de ces insectes au Congo. Dans les sections VIII et IX, nous nous sommes permis de dire, par où nous semblait pécher l'organisation actuelle du service médical du Congo et de faire en même temps quelques propositions pour l'améliorer.

Finalement nous décrivons l'état de choses en présence duquel nous nous sommes trouvés à Boma, Matadi, Léopoldville, Coquilhatville et Lusambo, et nous indiquons les mesures les mieux adaptées à chaque poste.

II. Biologie du Moustique.

Puisqu'il est acquis qu'il faut autant que possible détruire les moustiques, il est nécessaire d'étudier leur vie et leurs habitudes, de manière à établir quels sont les moyens les plus pratiques et les plus efficaces de les combattre. Bien que les moustiques aient tous le même développement, les habitudes des différentes espèces varient. Ce rapport négligera presque totalement une grande classe de moustiques, ceux qui vivent dans les champs, dans les forêts et en général dans la campagne, pour ne s'occuper que des genres qui se reproduisent dans les villes et dans les villages. Ce sont ces derniers en effet qu'il faut avoir en vue dans les questions de salubrité aux tropiques.

Nous exposerons d'abord brièvement les points communs de l'histoire de tous les moustiques africains. Nous considérerons ensuite les caractères particuliers à chacune des espèces qui nous intéressent spécialement.

La vie de tous les moustiques peut se diviser en quatre stades :

1. Le moustique à l'état d'oeuf
2. „ „ de larve.
3. „ „ de nymphe.
4. „ „ adulte.

Pendant les trois premières périodes, l'eau leur est absolument nécessaire.

La femelle prête à pondre recherche d'abord les endroits où il y a de l'eau ; puis s'étant mise dans la position voulue et s'appuyant sur un support quelconque, elle dépose ses oeufs à la surface de l'eau, en une masse qui ressemble vaguement à un radeau.

Les oeufs sont de forme ovale, très petits, capables de flotter et très nombreux. Une femelle peut en pondre jusqu'à 400 en une seule fois. Environ seize heurs plus tard chacun des oeufs éclôra et se transformera en une petite larve très active, très vorace, nageant à l'état libre et capable de se développer encore. Bien qu'elle puisse respirer l'air, la larve vit dans l'eau et elle meurt presque instantanément si on l'en retire et qu'on la laisse sécher. Elle monte à la surface à intervalles réguliers pour faire sa provision d'air. A cet effet elle est munie, à la partie postérieure du corps, d'un tube respiratoire.

Elle s'en sert pour percer la mince pellicule qui recouvre la surface de l'eau et, par ce canal, amener l'air jusque dans les voies respiratoires.

Au bout de cinq jours environ, la larve se transforme en une nymphe très active qui, à son tour, au bout de deux ou trois jours, devient un insecte adulte et prêt à prendre son vol.

Quand il fait une température chaude et que toutes les autres conditions sont favorables, la vie des moustiques, depuis l'état d'oeuf jusqu'à la période adulte, embrasse *grosso modo* une période minimum d'une semaine. Pendant tout ce temps l'eau est indispensable à leur développement. Il est bon de rappeler ici que, pendant la saison des pluies, des flaques d'eau qui disparaîtraient en un jour pendant la saison sèche, peuvent souvent croupir pendant plusieurs semaines et donner naissance à un grand nombre de moustiques. Les averses continuelles viennent en effet journellement compenser les pertes produites par l'évaporation.

Mais la présence, pendant une semaine, d'une masse d'eau quelconque, n'est pas à elle seule une condition suffisante pour créer un milieu favorable à la reproduction des moustiques. C'est ainsi que quelques moustiques seulement peuvent se reproduire dans l'eau salée, et que la grande majorité a besoin d'eau douce. Il ne faut pas non plus qu'il y ait dans l'eau trop d'ennemis naturels, tels que petits poissons et larves de certains insectes aquatiques, qui dévorent les oeufs des moustiques ainsi que leurs larves et leurs nymphes. Les eaux qui sont exposées à l'action du vent et dont la surface est constamment agitée, ne conviennent généralement pas non plus à la reproduction de l'espèce. Les eaux les plus propices sont celles dont la surface est abritée et où la femelle, au moment de la ponte, ainsi que le jeune adulte, au moment où il sort de la nymphe, ne courent pas le risque d'être détruits par les vagues.

C'est pourquoi, d'une manière générale, **les seules conditions favorables à la multiplication des moustiques sont les masses d'eau douce plus ou moins permanentes, abritées et dépourvues de poisson.**

Ces masses d'eau peuvent être soit artificielles, soit naturelles. Parmi ces dernières on pourrait citer les flaques d'eau isolées, qui se forment après une chute de pluie, et l'eau stagnante des marais. On voit aussi des larves des moustiques au bord des cours d'eau et des lacs, dans les empreintes de pas que laissent les animaux et dans les

baies ou criques, où l'épaisseur des roseaux et des herbes aquatiques les met à l'abri des petits poissons.

Comme milieux de reproduction artificiels, on pourrait citer les innombrables objets creux que l'on trouve aux abords de toutes les maisons et qui sont capables de retenir l'eau de pluie: Les vieilles bouteilles, boîtes, vieux pots et vieilles casseroles, les pirogues abandonnées, les puits peu profonds hors d'usage, tout cela favorise la reproduction, particulièrement pendant la saison des pluies. En outre les citernes, les pots à eau, les fosses d'aisances, les tranchées de drainage qui contiennent de l'eau en permanence pendant la saison sèche et la saison des pluies, renferment des moustiques à l'état de croissance.

Il est difficile d'établir avec certitude la durée de la vie d'un moustique adulte. La période pendant laquelle on peut garder des moustiques en vie dans une cage (2 à 3 mois), est beaucoup plus courte que la vie d'un insecte en liberté.

Il y a, à l'extrême nord et à l'extrême sud de l'Etat Indépendant du Congo, une saison séche qui dure plusieurs mois et pendant laquelle il n'y a pas de chutes de pluie ; les milieux favorables à la reproduction des moustiques y sont alors très rares, ou même n'y existent pas. Pourtant les moustiques résistent souvent à une saison séche comme celle-là. Quelquefois, pourrait-on dire, ils " hivernent," plongés dans un état d'indolence et d'inactivité. Mais il en est beaucoup qui peuvent rester actifs.

En cherchant bien, on peut les trouver dans cet état inactif dans les coins obscurs des chambres abandonnées, dans les irrégularités qu'offre le toit des chaumières des indigènes ou dans les encoignures où la lumière ne pénétre pas et où on ne vient pas les déranger. Dans ces circonstances ce sont les mâles qui vivent le moins longtemps. Les femelles prêtes à pondre, vivent plus longtemps. Il n'est pas douteux qu'un moustique puisse vivre ainsi de 5 à 6 mois, peut-être même davantage.

III. Moeurs des Moustiques.

Il importe de ne pas oublier que les moustiques qui transmettent les fièvres sont des insectes sédentaires. Bien qu'on cite des exemples de vol soutenu, en règle générale ils ne volent qu'à de petites distances et il est rare qu'on puisse sérieusement établir des cas de vols de plus

de 200 à 300 metres. **Si donc une maison est signalée comme contaminée par les moustiques, il est certain que le foyer d'infection se trouve dans le voisinage immédiat de l'établissement atteint.**

Une commission envoyée dans l'Afrique occidentale, par la Société Royale de Londres, pour étudier la malaria, pose en fait de la façon la plus péremptoire, que le vol des *Anophelinæ* n'est ordinairement que de 20 à 30 mètres et cite, comme tout à fait curieux, le cas isolé d'une maison, dont le foyer d'infection se trouvait dans une mare, située à 300 mètres de là.

On dit que, bien que la puissance du vol des moustiques soit limitée, le vent peut les transporter à de longues distances. C'est peut-être vrai pour des individus isolés ; mais la plupart de ces insectes restent cachés tant qu'il souffle une brise contre laquelle ils ne peuvent pas voler. Nous ne croyons pas qu'il puisse y avoir d'assez grandes invasions de moustiques amenées par le vent, pour décourager une campagne sérieusement entreprise contre eux, du moment qu'il s'agisse, bien entendu, d'une agglomération, d'une certaine étendue. Bien au contraire, des observations récentes semblent montrer que les grands vents tuent les moustiques. Il est sûr, en tout cas, que quand il souffle une forte brise, les moustiques se tiennent à l'abri dans toutes sortes de recoins. On peut toujours être sûr alors d'en trouver un ou deux dans les touffes d'herbe épaisses, dans les arbres mal écorcés, dans les décombres et dans les coins écartés. A ce point de vue il ne sera peut-être pas inutile d'insister sur le fait que dans les endroits ombreux qui entourent les habitations, les arbres peuvent tout au plus servir de lieu de retraite aux moustiques, mais pas de milieux de reproduction. Même comme abris, ils sont bien inférieurs aux appentis et dépendances, et attirent les moustiques beaucoup moins que les maisons. Il est possible que leur feuillage amène quelques moustiques, mais la protection qu'ils offrent contre le soleil compense amplement le petit mal qui en résulte, et le remède le plus efficace réside bien plus dans les opérations dirigées contre les insectes eux-mêmes.

Mais, si le vent ne peut pas apporter un assez grand nombre de moustiques susceptibles de se reproduire pour qu'ils constituent un danger, les moyens de transport introduits par l'homme, trains, bateaux et voitures, peuvent colporter l'infection dans les localitiés

non encore atteintes. C'est ce qu'on a constaté d'une manière frappante en Amérique et ailleurs, dans les endroits où l'on a établi des services rapides et directs de chemin de fer du bord de la mer aux villes de l'intérieur ; on a vu en effet des régions montagneuses qui se sont trouvées ainsi infectées par des moustiques venus du bord de la mer. De la même manière on trouve des moustiques des régions tropicales en Europe, où ils sont apportés dans la cale des vaisseaux venus du Sud. En Italie les diligences se sont trouvées être des distributeurs de moustiques dangereux. Dans l'Etat Indépendant du Congo, il est notoire qu'une quantité énorme de moustiques se développent souvent dans l'eau qui séjourne à la cale des steamers fluviaux. Aussi le nombre des moustiques augmente-t-il fréquemment dans les stations fluviales, aussitôt après l'arrivée d'un steamer.

Certaines personnes croient encore à tort que les moustiques peuvent se reproduire dans la terre humide et dans l'herbe. Il n'en est rien, comme il ressort de ce que nous avons dit plus haut. Les partisans de cette doctrine donnent comme preuve à l'appui, le grand nombre de moustiques que l'on voit, soit dans l'herbe qu'on vient d'arroser, soit dans le voisinage de cette herbe, ou bien encore dans les jardins. Ils oublient que les moustiques boivent l'eau et que mâles et femelles également sucent le suc des fruits et des plantes. En outre l'humidité pourrait fort bien attirer les femelles prêtes à pondre et en quête d'eau où elles quissent déposer leurs œufs.

Nous venons de dire que les moustiques, tant mâles que femelles, se nourrissaient du suc des végétaux. On a vu des moustiques des deux sexes mordre d'autres insectes, mais la femelle seule suce le sang des oiseaux et des autres animaux. Cette habitude de la femelle est d'une très grande importance pour la reproduction de l'espèce, puisque ce n'est souvent qu'après s'être gorgée de sang qu'elle produit ses ovules.

Nous avons esquissé les points principaux de la vie et des habitudes des moustiques. Nous allons indiquer maintenant, en quoi les genres qui nous intéressent particulièrement, s'écartent de la règle générale.

Genre *Culex*.

Milieux de reproduction :—De nombreuses espèces de *Culex* et de *Stegomyia* sont souvent de vrais moustiques domestiques. Ils déposent leurs œufs dans n'importe quelle flaque d'eau, quel qu'en soit le degré

de stagnation et de saleté, et quand même le voisinage serait des plus bruyants. Ce sont eux qui se multiplient si rapidement dans les petites flaques d'eau si fréquentes à la saison des pluies et qu'à une autre saison une journée de soleil suffirait à dessécher. Ce sont eux dont on trouve si souvent les larves, les œufs et les nymphes dans les cuveaux, dans les vieux vases, dans les citernes, au rebord des toits et dans les fosses d'aisances. Ils se reproduisent de préférence dans les fontaines et les tranchées de draînage à ciel ouvert.

Outre ces milieux artificels de reproduction, ils se multiplient par millions dans les milieux naturels et, pour ainsi dire, dans n'importe quel endroit où il y a de l'eau d'accumulée.

Le *Culex* adulte mord également la nuit et le jour, bien que ce soit peut-être immédiatement avant et après le coucher du soleil qu'il absorbe la plus grande quantité de nourriture.

Le *Culex* et le *Stegomyia* peuvent se trouver dans les maisons d'habitation pendant le jour, soit qu'ils volent, soit qu'ils se reposent sur les habits ou sur les murs et dans les endroits où l'on ne va que rarement.

Bien que le *Culex*, comme espèce, ait un vol plus puissant que le *Stegomyia* ou l'*Anophelina*, il évite même les courants d'air les plus légers, celui que produit une "punka"* par exemple. Et peut-être ne sera-t-il pas hors de propos de faire remarquer quelle sérieuse protection peut offrir une punka constamment remuée contre la morsure des moustiques.

Genre *Stegomyia*.

Ce moustique, le moustique de la fièvre jaune, est reconnaissable aux bandes blanches qu'il porte sur les pattes; c'est le moustique domestique par excellence. Souvent il dépose ses oeufs dans les cruches d'eau qui se trouvent dans les pièces où il habite et dont les occupants lui servent de nourriture.

Il pique le plus communément assez tôt dans l'après-midi (de 2 à 3), bien qu'il le fasse aussi la nuit.

Genre *Anophelina*.

Bien que l'*Anophelina* adulte soit souvent un "moustique domestique" il lui faut en général, pour se reproduire, un endroit plus écarté que dans le cas du *Stegomyia* et du *Culex*. On ne l'a pas encore vu se reproduire à l'intérieur des maisons. D'ordinaire on

* Sorte de ventilateur hindou, suspendu au plafond et que l'on met en movement en tirant sur une corde.

trouve ses larves dans les flaques d'eau qui ne sont pas tout à fait stagnantes, au bord des marais et des cours d'eau, dans les fossés dont le courant est ralenti par la végétation, dans les mares tranquilles des jardins, ou bien dans les fontaines, les cuveaux et les barils où l'on prend rarement de l'eau.

L'*Anophelina* adulte est par essence un moustique domestique, d'habitudes nocturnes et qui ne se déplace pas beaucoup. Elle mord le plus souvent la nuit et, pendant le jour, reste cachée à une petite distance des endroits où elle trouve sa nourriture. On peut dire sans crainte de se tromper qu'on peut toujours trouver les *Anophelinæ* dans les cases des indigènes. Une fois éclose dans une des nombreuses flaques d'eau qui se trouvent si fréquemment aux abords des villages, la femelle gagne la case d'un indigène et ne la quitte que lorsqu'elle est prête à déposer ses oeufs.

La nuit, elle se repaît du sang des habitants endormis ; le jour elle reste cachée dans les innombrables fissures qui se trouvent dans les toits de chaume et ne se laisse découvrir qu'au prix des recherches les plus attentives.

Dans les maisons d'Européens, elle se retire dans les coins obscurs, sous les lits, dans les vêtements, derrière les cadres et dans les plis de rideaux.

Elle se cache tellement bien que ceux mêmes qui lui servent de pâture nient sa présence. Les personnes qui ont été très souvent piquées par les moustiques acquièrent d'ailleurs un grand degré d'immunité contre l'irritation produite par la piqûre de ces insectes. Il ne se produit souvent qu'une inflammation très passagère, ou même rien. Le matin, comme on ne voit ni moustique ni traces de piqûres la victime admet par principe qu'il n'y en a pas dans sa maison.

Dans les Tropiques on fera bien de tenir compte des points suivants, dans l'aménagement des maisons pour les Européens. Les moustiques craignent le vent et recherchent les coins où règne l'obscurité, pour se cacher, se reposer et faire leur digestion. Faites donc usage de punkas, créez des courants d'air, et les moustiques ne se plairont pas dans vos appartements. Badigeonnez vos murs avec des couleurs vives, le vert tendre et le gris bleu très pale par exemple, qui sont trop claires pour inviter les moustiques à s'y poser, et qui ne fatiguent pas trop la vue. Pas de draperies non plus, telles que rideaux épais, habits exposés à l'air, couvertures de lit tombantes, en

un mot rien qui fasse des plis pouvant offrir une retraite aux moustiques. Qu'il y ait aussi peu d'endroits que possible où la lumière ne pénètre pas, sous les lits, derrière les meubles et les cadres, par exemple. Ayez de grandes fenêtres et assurez l'aération de vos pièces.

Quant aux maisons on ne devrait les construire qu'à une bonne hauteur au-dessus du niveau du sol; en fait, le plus haut sera toujours le mieux. On devra veiller à ce que l'air circule librement au-dessous des parquets, avoir soin de tenir cet espace dans un état de propreté et de sécheresse scrupuleuses (en les badigeonnant par exemple), et sous aucun pretexte, on ne s'en servira pour remiser de vieux ustensiles. Les maisons doivent être protégées autant que possible contre l'invasion des moustiques. Chaque porte ou fenêtre serait munie d'un châssis couvert de toile métallique. Il peut ne pas être toujours possible de protéger ainsi toute la maison ; dans ce cas il devrait y avoir en chaque domicile une chambre complètement abritée des moustiques. En somme le moyen de diminuer le nombre des moustiques qui fréquentent les établissements des tropiques, c'est d'augmenter la difficulté qu'ils ont à trouver leur nourriture et à se cacher, une fois repus.

Qu'on n'oublie pas, en lisant la description des mœurs de ces insectes, qu'il s'agit d'êtres vivants, capables, par conséquent, d'une certaine initiative. Nous avons mentionné les habitudes de chaque espèce. Il ne s'ensuit pas que des individus isolés ne puissent se départir des habitudes de la majorité, et que même une espèce tout entière ne puisse, dans des circonstances exceptionnelles, modifier son mode de vie. Ainsi les *Anophelinæ* préfèrent l'eau claire des mares calmes et peu profondes, où il pousse beaucoup d'herbe ; mais, en cas de besoin, ils se reproduisent dans les cuveaux et les fontaines où on puise souvent de l'eau, ou encore dans les flaques d'eau croupissante.

Si donc nous appliquons la connaissance que nous avons des mœurs des moustiques à leur destruction, il ne faudra pas oublier ce caractère de versatilité. **Toute masse d'eau devra être considérée comme suspecte de favoriser la reproduction** et on ne la déclarera libre de larves, qu'après examen sérieux par une personne compétente. Il est donc nécessaire, avant d'entreprendre une campagne intelligente contre les moustiques, de nommer des inspecteurs, à qui on aura appris à reconnaître et à trouver les larves.

IV. Destruction des Moustiques.

Comme nous l'avons remarqué, les premières périodes de la vie de tous les moustiques doivent se passer dans l'eau et loin du menu fretin. C'est le point faible de l'évolution de ces insectes. Empêchez-les de pénétrer en eaux protégées, et leurs ennemis naturels les auront bientôt exterminés. L'objet qu'on devra avoir principalement en vue, dans l'amélioration de l'état sanitaire des villes des Tropiques, devra donc être, de prendre des mesures permanentes pour empêcher l'eau de s'accumuler et de former ainsi, dans le voisinage de ces villes, des milieux propres à la reproduction des moustiques. On devra par conséquent combler les marécages, donner aux tranchées de draînage une pente régulière, et un lit égal, de façon qu'il ne s'y forme pas de flaques d'eau ; on y fera également passer des chasses d'eau toutes les semaines. On comblera tous les trous, ainsi que les dépressions de toute nature où l'eau pourrait séjourner. On détruira soigneusement tout ce qui serait susceptible de retenir l'eau comme vieilles faïences, bouteilles, boîtes, cuveaux et pirogues.

S'il est impossible d'empêcher la formation des masses d'eau dangereuses, il faudra empêcher les moustiques d'y pénétrer, en tendant soigneusement de la gaze métallique (7 mailles au cm.). Ou bien on traitera l'eau toutes les semaines au pétrole brut (température de combustion 65°C.). Pour cela on versera à la surface de l'eau 10ccm. de pétrole par mètre carré. Le pétrole se répand alors et forme une fine pellicule. Quand les larves montent à la surface pour respirer, il s'introduit des globules de pétrole dans leurs organes respiratoires et, l'air venant à leur manquer, elles meurent étouffées. Cette pellicule de pétrole ne dure malheureusement pas toujours. Il faut la renouveler toutes les semaines, et même plus souvent, lorsqu'elle a été emportée par de fortes pluies. Les citernes d'eau potable peuvent se traiter de la même façon ; seulement il faudra prendre soin de les munir d'un robinet à leur partie inférieure, pour tirer l'eau qui n'aura pas été abimée par le pétrole.

On peut également écarter, dans une assez grande mesure, le danger qui provient des nappes d'eau dormantes et marécageuses qui se trouvent dans les cours d'eau. Il suffit pour cela d'enlever les herbes et la végétation, qui d'ordinaire protègent les larves contre le menu fretin.

3° qu'ils mordent principalement la nuit ;
on aboutira à un principe qui devrait recevoir la plus grande attention, toutes les fois qu'on s'occupe de propagande sanitaire dans les établissements d'Européens, celui de *la séparation des races.*

Le blanc ne devrait pas habiter dans le voisinage immédiat des noirs. Il devrait y avoir un quartier réservé aux blancs, et un autre aux noirs, et il devrait y avoir, entre les deux, un intervalle d'au moins 400 mètres, ou même de 800 et plus, si c'est possible.

C'est ce qui a toujours été le cas aux Indes. Les Hindous, heureusement pour les Européens, refusent, pour des raisons de caste, de vivre dans le voisinage des blancs. C'est une des raisons pour lesquelles la malaria est si rare dans certains cantonnements européens de l'Inde.

Les partisans de la séparation des races en Afrique, comme mesure prophylactique contre la malaria, dans les agglomérations de blancs, ne prétendent point qu'il faille éviter les indigènes et n'avoir aucun rapport avec eux Ils ne veulent pas dire non plus, qu'il n'y a pas lieu de faire profiter aux Africains des avantages déjà acquis, ni de les faire bénéficier des mesures prophylactiques qui reposent sur la destruction des moustiques. Ce qu'ils demandent simplement, c'est une sauvegarde de plus pour le blanc, et ils insistent sur ce fait que sa maison devrait toujours être située loin des cases des indigènes. De cette façon, les affaires de la journée une fois expédiées, il pourra retourner chez lui en toute sécurité et être à l'abri des *Anophelinæ* infectés.

Au Congo il n'y a pas encore de grandes villes. Dans quelques-uns des postes les plus importants, on a déjà tenté de séparer les blancs des noirs. A mesure que les villes se développeront, on pourra facilement appliquer cette mesure et il en résultera des agglomérations idéales.

VII. Législation.

Pour mener à bien la campagne contre les moustiques, il faut des lois ou des réglements municipaux et, plus la loi sera simple, plus elle aura de chances d'être observée. Il devrait y avoir tout d'abord une première clause, établissant **qu'il sera illégal pour tout individu de permettre la reproduction des moustiques dans l'enceinte de ses locaux** et que toute infraction à ce réglement sera punie.

Il sera nécessaire, bien entendu, pour soutenir cette prohibition, de spécifier point par point quelles sont les conditions à éviter pour favoriser la reproduction des moustiques. Il faudra des réglements prévoyant la suppression des mares d'eau stagnante ainsi que des fontaines inutiles, la protection des citernes, réservoirs, etc.

Pour appliquer ces réglements, il faudra créer les Inspecteurs spéciaux, qui auront le droit d'entrer dans les locaux appartenant aux particuliers, et de faire des visites domiciliaires de maison en maison, tout comme les Inspecteurs de la Santé.*

Il faudra surveiller de près les reservoirs dans les cases des indigènes, et on fera comprendre aux indigènes qu'on peut empêcher les moustiques de se reproduire dans ces ustensiles, soit en les couvrant soigneusement, soit en les vidant complètement deux fois par semaine. A Cuba, les vases et récipients où on avait déjà trouvé des larves et où on en retrouva une deuxième fois, furent confisqués et brisés et les tessons enlevés.

Dans la construction des réservoirs de toute sorte, on devra imposer comme condition, qu'ils soient inaccessibles aux moustiques. Il faudra faire aussi des lois ne permettant de creuser de puits ou fontaines dans les limites de la ville, que sur autorisation spéciale, et, de plus, établir des mesures obligeant les habitants à combler leurs vieux puits ou fontaines.

Quelque réglements que l'on adopte, il ne faut pas oublier qu'il sera absolument nécessaire de créer des Inspecteurs ayant reçu une instruction spéciale pour en assurer l'application. Les larves de moustiques peuvent être tout aussi dangereuses et tout aussi désagréables pour les agglomérations d'habitants, que l'accumulation des tas d'ordures. Les Inspecteurs du Service de la Santé Publique devront se faire un devoir de veiller à la déstruction des unes tout aussi bien qu'a l'enlèvement des autres.

L'organisation à demi militaire de l'Etat Indépendant du Congo facilitera singulièrement la mise en vigueur des mesures qui devraient être prises par les autorités de tous les pays chauds. Pour assurer l'observation des mesures sanitaires par les particuliers, il sera bon de publier des brochures sur la question, et de les répandre par

* Il suffirait d'apporter aux lois existantes des modifications insignificants, pour donner au service sanitaire tous les pouvoirs nécessaires.
Voir "Recueil usuel de la législation de l'État Indépendant du Congo."

l'intérmédiaire des maisons de commerce, des missionnaires et des fonctionnaires. Elles devront exposer en une langue simple et claire, comment les maladies des tropiques, et en particulier la malaria, se propagent par l'intermédiaire des moustiques, et comment il faut s'y prendre pour éviter ces insectes ou les détruire. On pourra encore avoir recours aux conférences, que pourraient faire sur le sujet les médecins régionaux et qui ne sauraient manquer d'être utiles.

Un autre moyen de répandre les idées, ce serait de rééditer les publications de l'Etat Indépendant du Congo, qui traitent des questions de salubrité publique. Nous songeons particulièrement au " Recueil administratif " et au " Manuel du voyageur et du résident au Congo." Les résultats des dernières recherches sur la maladie du sommeil devront également y trouver place.†

VIII. Organisation du Service Medical dans l'Etat Indépendant du Congo.

Pour assurer l'application efficace des mesures que nous venons d'indiquer, il est évident qu'il faudra, dans chaque poste, une assez forte équipe d'ouvriers. Ces hommes feront partie des différents services sanitaires municipaux, et seront naturellement sous les ordres du médecin local du gouvernement.

A l'heure actuelle le service médical de l'Etat Indépendant du Congo se compose presque exclusivement d'hommes qui sont bien qualifiés pour exercer la médecine en Europe, mais qui n'ont pas étudié spécialement la médecine tropicale.

Pendant les dix dernières annèes, les progrès accomplis dans cette branche de la médecine ont été énormes. Le diagnostic, le traitement et la prophylaxie des plus importantes maladies des pays chauds ont été renouvelés.

Nous n'hésitons donc pas à affirmer que les médecins ordinaires qui viennent de sortir de l'Université ne sont pas à même d'exercer utilement leur profession dans les Tropiques, à moins de recevoir une instruction spéciale. Nous croyons également, qu'ils ne peuvent apprendre le traitement des maladies des pays chauds que dans une école spéciale de médecine tropicale. Nous sommes de l'avis du Dr.

† Memoire XVIII, Liverpool School of Tropical Medicine.

Firket,* qui pense, que cette étude se fera de la manière la plus profitable, lorsque les étudiants se seront déjà familiarisés avec les autres branches de la médecine. En quelques semaines de travail soutenu, la plupart des médecins pourront s'assimiler la plupart des points importants de la médecine tropicale, et apprendre à résoudre les difficultés imprévues qui ne manqueront pas de se présenter pendant leur séjour aux Colonies.

Nous recommandons qu'à l'avenir on ne nomme pas, dans l'Etat Indépendant du Congo, de médecins qui n'auront pas suivi un cours spécial de médecine et d'hygiène tropicales et qui n'auront pas passé leurs examens d'une manière satisfaisante. En Angleterre, les candidats au poste de médecin des Colonies dans la zone torride, doivent être diplômés d'une école de médecine tropicale anglaise. Les candidates, qui sont par ailleurs qualifiés pour l'exercice de la médecine, sont envoyés aux frais du gouvernement dans une école de médecine tropicale de leur choix. En cas d'échec dans leurs examens, la nomination n'est pas confirmée.

Peut-être serait-il possible d'engager les médecins qui sont déjà au service de l'Etat, à suivre des cours dans une école spéciale de médecine tropicale.

La pratique de la médecine n'est pas attachée à des régles fixes, immuables. Les recherches que l'on fait constamment aboutissent sans cesse à de nouvelles découvertes. Le médecin qui voudra faire profiter ses malades des progrès de la science ne devra donc pas cesser d'étudier. Au Congo, loin des bibliothéques et des écoles, les médecins doivent forcément rester dans l'ignorance des découvertes qui se font dans leur métier, et ils s'en rendent bien compte. Il en est qui passent une partie de leurs congés à étudier en Europe, une fois leurs trois années d'Afrique écoulées ; il en est d'autres qui ne le font pas. Il est certes de la plus grande importance que le service médical du Congo soit aussi efficace que possible. Nous recommanderions donc d'envoyer, tous les cinq ans, les médecins coloniaux étudier dans les écoles de médecine tropicale, en leur payant, bien entendu, intégralement leur traitement. En Angleterre, on donne de cette façon des " congés d'études."

* Du rôle de l'enseignement médical dans la préparation à l'expansion économique. Rapport présenté au Congrès d'expansion mondiale, à Mons (1905), par M. le Dr. Ch. Firket, Professeur à l'Université de Liège.

En Afrique même, on devrait expédier de temps en temps aux médecins les livres et les publications contenant la description des découvertes les plus importantes. Ils pourraient ainsi se tenir utilement au courant.

Le service médical de l'Etat Indépendant du Congo manque d'organisation dans l'ensemble. L'Officier médical est sous les ordres directs du Chef du district auquel il est attaché. C'est, sans doute, un système qui s'impose, dans les postes éloignés et dans les régions nouvellement ouvertes. Nous croyons cependant que le temps est venu, dans les villes et dans les postes les plus importants, de faire du service médical un départment indépendant, le Départment de la Santé Publique.

Nous suggérerions la création d'un Officier de Santé Principal. Avec les officiers déjà stationnés à Banana, Matadi, Boma, Léopoldville, et peut-être Coquilhatville, on assurerait ainsi, pour la partie professionnelle, le service de la santé publique au Bas-Congo. Ce n'est pas ici le lieu de définir les pouvoirs qui reviendraient à ce département, ni la façon de les exercer. Il ne serait pas utile non plus d'essayer d'indiquer en détail quelles seraient les fonctions de l'Officier de Santé Principal. Nous ne ferons donc qu'indiquer les grosses lignes.

L'Officier Principal s'occuperait de l'administration du service médical et des questions d'hygiène publique, plutôt que du traitement des malades.

En matière professionnelle son attitude vis-à-vis de ses confrères ne saurait être celle d'un critique ; et les médecins locaux seraient libres de lui demander son avis ou son assistance en cas de besoin. Le traitement des maladies courantes serait entièrement laissé à leur charge.

L'Officier Principal inspecterait les hôpitaux déjà existants, et donnerait son avis sur le plan et le site des hôpitaux et des camps d'isolement projetés. On aurait à le consulter dans toutes les questions concernant directement la santé publique, comme service des eaux, drainage, construction des maisons d'habitation, choix du site des villes et des postes, construction d'égouts, emplacement et disposition des marchés, inspection des denrées alimentaires. Il dirigerait en outre le service de statistique médicale. Il prescrirait les mesures à prendre en cas de danger d'épidemie. Il transmettrait

au Governeur Général, en y ajoutant ou non son approbation, les rapports et les recommandations de ses subordonnés en matière médicale. Bref, il serait, en Afrique, le principal conseiller médical du Gouvernement de l'Etat Indépendant. Il adresserait ses rapports en double au Chef du district en cause et au Gouverneur Général ou à son représentant en Afrique, mais ne serait appelé à rendre de comptes qu'à ce dernier.

Ce serait encore une de ses fonctions d'aller en tournée d'inspection, deux fois par an, dans les postes les plus importants de son district. Il discuterait alors, avec les autorités locales, l'état sanitaire général du poste et aviserait avec eux, en cas de besoin, aux moyens d'amélioration. Sa première visite dans chaque poste, comporterait un examen complet des lieux, et il indiquerait les mesures à prendre pour prévenir les maladies.

Comme on le voit, le poste d'Officier Principal de santé ainsi conçu, demandera beaucoup de tact et exigera un homme versé dans toutes les questions de médecine et d'hygiène tropicales, et au courant des méthodes modernes.

Les devoirs des médecins dans les différents postes, resteraient sensiblement ce qu'ils sont à présent. On a donné certains pouvoirs judiciaires aux médecins de l'Etat Indépendant du Congo. Nous pensons que dans les postes les plus importants du Bas-Congo on pourrait les en dispenser, de façon à leur enlever cette responsabilité.

On leur demanderait, une fois qu'ils seraient passés par l'école de médecine tropicale, de faire l'examen de leur poste au point de vue de la malaria, et de diriger les travaux de l'équipe employée par le Département de la Santé Publique, à la destruction des moustiques.

On leur demanderait :—

(1) de savoir combien il y a de cas de malaria dans leur poste, chez les blancs et chez les noirs ;

(2) de se renseigner exactement sur la quantité d'*Anophelinæ* présents, et sur la proportion de ceux qui colporteraient la malaria,

(3) de connaître leurs milieux de reproduction.

Ils devraient en outre veiller à l'exécution des mesures qu'ils auraient, de concert avec l'Officier Principal, décidé de prendre pour la destruction des moustiques.

Il leur faudrait, dans ce but, un certain nombre d'outils et de matériaux, et ils auraient à leur disposition une équipe consistant,

IX. La Statistique Médicale dans l'Etat Indépendant du Congo.

Dans l'Etat Indépendant du Congo, on n'a fait aucun effort pour réunir des statistiques, permettant d'établir la morbidité et la mortalité dans les différents postes. On enjoint bien aux médecins de faire régulièrement des rapports sur l'état sanitaire général de leur station ; mais il n'y a pas de forme prescrite et la nature de leurs rapports dépend en grande partie d'eux-mêmes.

Il est inutile d'insister sur l'intérêt que présenteraient des statistiques bien faites. Tous les médecins de l'Etat Indépendant, croyons-nous, devraient être invités à envoyer tous les trois mois un rapport sur l'état sanitaire de leur poste.

Ce rapport contiendrait les renseignements suivants:

Mouvement de la population blanche et de la population nègre. On indiquerait à part le chiffre de la population stationnaire et celui de la population flottante. On rangerait sous des rubriques spéciales les cas de maladies chez la population flottante, et on ne considérerait pas ces maladies comme ayant pris naissance dans le poste où le malade aurait été observé. Pour plus d'uniformité on ferait bien de classer les maladies suivant une nomenclature indiquée par le chef du Departement de la Santé Publique. Nous proposerions de classer les fièvres malariennes comme fièvre simple, fièvre tierce, fièvre quarte, fièvre estivo-automnale ; on devra indiquer en plus comme manifestations secondaires les accès pernicieux et l'hémoglobinurie (" Blackwater fever "), etc. Il faudrait spécifier dans chaque cas, comment on a établi le diagnostic, si c'est au moyen du microscope ou autrement, et dire si le malade a été atteint pour la première fois ou si c'est une rechute.

A la fin de l'année on réunirait tous ces rapports ; ils seraient publiés sous forme de volume par les soins de l'Officier de Santé Principal et ils formeraient une des parties principales du Rapport Annuel du Département de la Santé Publique. La valeur d'une série de rapports ainsi faits, rien que pour se rendre compte des progrès accomplis, serait inestimable. On pourrait établir un système d'échanges entre l'Etat Indépendant du Congo et les autres gouvernements de la zone torride. Le Département de la Santé Publique enverrait ses rapports, et recevrait en retour les publications faites sur la matière dans toutes les parties du monde. De cette façon on se communiquerait le

résultat des expériences faites en différents endroits et l'Officier de Santé Principal serait tenu au courant des progrès accomplis en médecine tropicale ailleurs qu'au Congo.

X. Rapports Spéciaux sur quelques-uns des Principaux Postes de l'Etat Indépendant du Congo.

Nous avons décrit l'état de choses en présence duquel nous nous sommes trouvés, lors de la visite que nous avons faite dans chaque poste. Nous avons indiqué certaines mesures à prendre, et nous nous sommes efforcés de rendre nos recommandations aussi pratiques et aussi bien adaptées que possible aux circonstances. Dans quelques cas, les méthodes qui auraient été les plus efficaces nous ont paru trop difficiles à exécuter, en général pour des raisons pécuniaires. Toutes les fois que cela nous a paru possible, tous avons proposé le système le moins dispendieux.

Nous voudrions voir introduire au Congo un système d'assainissement rationnellement organisé. Dans l'espoir qu'on en adopterait un, nous avons conseillé les remèdes les plus simples et les plus économiques. C'est ce qui fait que nous avons si rarement recommandé l'usage du pétrole. C'est pour la même raison que nous n'avons pas discuté la possibilité de réduire les ravages de la malaria en donnant de la quinine à toute la population d'une région.

Qu'il soit bien entendu que les renseignements fournis par nos enquêtes dans les différents postes, exacts à l'epoque ou nous les avons obtenus, auront besoin d'être complétés à l'avenir par des hommes compétents. De la même manière, les mesures que nous recommandons, devront être mises à exécution par des médecins spécialement préparés pour ce genre de travail, et capables d'apprécier l'importance du travail qui leur sera confié. Nos recommandations n'auront d'autre but que d'indiquer la marche à suivre pour assurer aux employés de l'Etat Indépendant les moyens de profiter des dernières découvertes de la science dans les questions d'hygiène tropicale.

Nous tenons à dire ici que nous sommes redevables de bon nombre de faits sur le climat et l'état sanitaire des différents postes, à l'exposé des Drs. Bourguignon, Cornet, Drycpondt, Firket et Meuleman, intitulé : " Rapport sur le climat, la constitution du sol et l'hygiène du Congo," et présenté au Congrès National d'Hygiène et de Climatologie tenu à Bruxelles en 1897.

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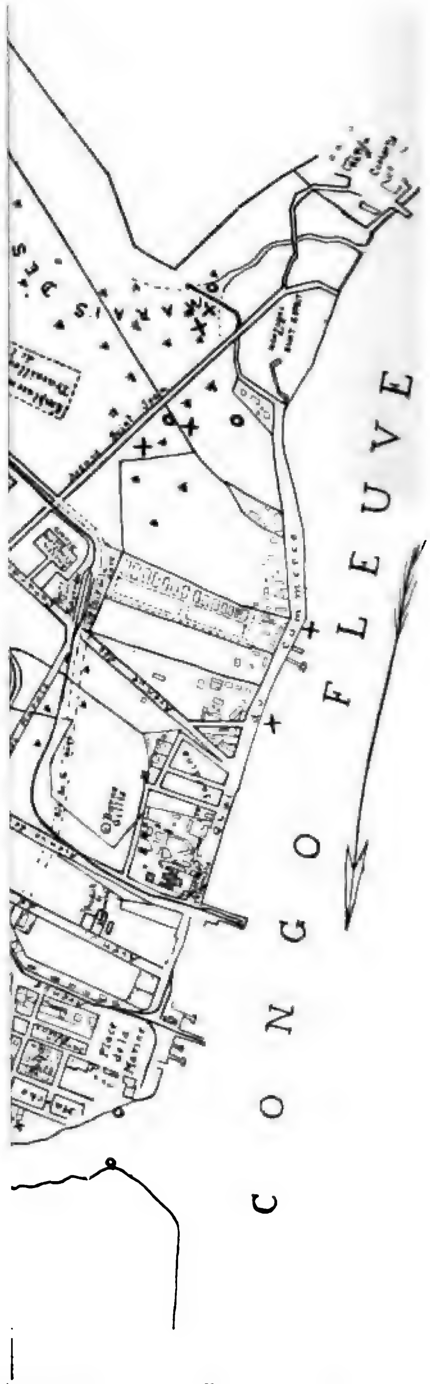

Il n'existe pas au Congo de service de statistique médicale. Un grand nombre des allégations que nous faisons sur les questions d'hygiène publique, reposent sur les renseignements fournis par divers fonctionnaires, médecins et autres, dans les postes visités. Koch a montré que l'on pouvait établir avec exactitude la fréquence de la malaria dans une localité donnée, en déterminant le proportion d'enfants indigènes résidents de moins de dix ans, qui en sont atteints. Le chiffre ainsi obtenu prend le nom d' " Index endémique." Les statistiques médicales faisant toujours défaut au Congo nous avons été obligés d'avoir presque exclusivement recours à ce moyen pour établir la fréquence de la malaria.

Rapport sur Boma.

Boma est la capitale politique de l'Etat Indépendant du Congo, et ce sera sans doute quelque jour une ville importante. Aussi ne devrait-on la developper que sur un plan bien défini, si l'on veut qu'elle soit saine et réellement habitable. Il faut fixer l'emplacement du quartier européen et du quartier africain et s'arrêter à un programme défini d'améliorations à apporter dans la ville. Seuls des règlements rationnels, consciencieusement appliqués peuvent assurer la santé aux futurs habitants de Boma.

Il est facile de choisir une douzaine de villes parmi celles qui s'élèvent sur la côte de l'Afrique Occidentale, pour montrer les inconvénients qu'offre la construction des villes en dehors de toute réglementation dans les Tropiques. A Conakri, au contraire, on peut apprécier les avantages économiques qu'offre l'application des principes d'hygiène tropicale dans la construction des villes.*

Boma devant prendre de l'importance à l'avenir, nous nous étendons davantage sur cette ville, et nous recommandons de prendre des mesures d'une nature plus permanente et aussi plus coûteuses que dans les autres postes.

1. SITUATION, DISPOSITION ET ENTRETIEN DU POSTE.

Boma est située sur la rive droite du Congo, à environ 30 kilomètres de son embouchure, et à une altitude de 24 mètres au-dessus du

* Voir Mémoire XIV de l'École de Medicine Tropicale de Liverpool.

niveau de la mer. On n'y sent donc pas la marée et l'eau du fleuve est douce. La différence entre l'étiage et la hauteur maxima des eaux du fleuve est de 4 mètres environ. A Boma même le fleuve ne déborde jamais. La rapidité du courant varie de 5 à 6 nœuds à l'heure ; si les berges sont bien entretenues, et qu'on enlève l'herbe, les moustiques ne pourront pas se reproduire dans le fleuve.

A Boma le Congo est profond et il n'y a pas de bancs de sable qui en interrompent le cours. Il a une largeur de 5 Kilomètres environ. Juste en face de Boma il y a une île appartenant au Portugal. Le bras du fleuve entre Boma et l'île a à peu près un kilomètre de largeur ; il n'y a donc pas de danger que les moustiques nés dans les marais de l'île viennent jusqu'à Boma.

Les saisons sont loin d'être régulières. On parle couramment d'une longue et d'une courte saison des pluies, et on en dit autant de la saison sèche. En fait on peut dire que, de mai à septembre, il ne tombe que peu d'eau ; et que, d'octobre à la fin d'avril, il en tombe beaucoup. La chaleur se fait le plus sentir de janvier à avril. La saison la plus favorable aux moustiques s'étend donc à peu près du mois d'octobre au mois de mai.

C'est aussi, à peu de chose près, l'époque des hautes eaux. Le sol n'étant pas très poreux, l'eau séjourne alors dans les bas-fonds mal drainés.

A l'heure actuelle Boma consiste de deux parties, Boma-Plateau et Boma-Rive. Le plateau est d'un draînage facile. C'est là qu'on a construit la résidence des fonctionnaires et quelques-uns des bureaux du gouvernement. Boma-Rive, comme son nom l'indique, est la partie basse, qui borde le Congo. On y voit un grand nombre d'établissements commerciaux, quelques édifices publics et des résidences particulières de blancs et de noirs.

Il y avait autrefois de grands marais entre le plateau et la basse ville. C'est ainsi qu'à la saison humide les communications ne se faisaient que par bateau, ou par une chaussée très étroite. Ainsi les ouvriers qui ont bâti l'Avenue de la Force Publique se rendaient en pirogue à leur travail. Différents gouverneurs ont comblé les marais, et, au sud-ouest du plateau, on a reconquis une partie du terrain sur lequel s'élèvent maintenant des maisons. Cependant il y en a encore, à l'intérieur du poste, un ou deux marais qu'on ne saurait trop tôt remplir.

Si le Congo ne déborde pas, il arrive assez fréquemment qu'un autre cours d'eau, la Rivière des Crocodiles, qui borne Boma à l'ouest, inonde le quartier de la ville qui lui est contigu : la place de la Marine, le Marché et rue de la Rivière. Ceci se produit au moment des hautes eaux du Congo. La différence de niveau entre le poste et le fleuve est alors très petite. La Rivière des Crocodiles faisant une courbe très brusque avant de se jeter dans le Congo, ne profite alors qu'en partie de la pente. Après une forte pluie, le volume de la rivière augmente quelquefois soudainement, et comme elle est arrêtée par une langue de terre qui s'avance dans le fleuve à son confluent avec le Congo, elle déborde. Il arrive parfois qu'elle monte de 3 à 4 mètres dans l'espace de quelques heures. Il paraît même qu'alors l'eau recouvre quelquefois le bas de l'Avenue Royale. Les ingénieurs du gouvernement proposent de percer un canal dans la presqu'île, qui permettrait à la rivière de se déverser directement dans le Congo.

La population de Boma est très flottante. Boma est la capitale du Congo et port d'escale en même temps. C'est donc le point de départ et d'aboutissement de bien des opérations. On dit qu'il s'y trouve de 2 à 400 Européens et de 1 à 3,000 Africains. Bien qu'à l'époque de notre visite à Boma il n'y eût pas officiellement de quartier nègre, la plupart des indigènes habitaient assez loin du quartier européen, dans les villages de la Montagne du Saint-Esprit, de " Samuel," etc. Pourtant un grand nombre d'entre eux habitaient dans le quartier où résident la plupart des Européens. Dans les maisons de commerce c'était l'usage pour les ouvriers d'habiter sur les lieux avec leur famille. Sur le plateau même il y avait quelques groupes de cases, occupées par les serviteurs des fonctionnaires. La prison et le camp des soldats indigènes (250 hommes environ et leurs familles), sont beaucoup trop près des maisons des blancs à Boma-Plateau. De l'autre côté de la Rivière des Crocodiles et juste en face de la prison, se trouve une spacieuse vallée, qui donne d'un côté sur Boma Plateau et la rivière, et qui, des trois autres, est abritée par des collines. Le centre en est assez marécageux. On a proposé d'assigner le bas de la vallée aux ouvriers de l'Etat, qui le cultiveraient pour leur propre compte, et de leur bâtir des maisons de briques en haut de la vallée.

C'était une excellente idée, puisqu'elle supprimait à la fois les milieux de reproduction des moustiques, et qu'elle transportait à 800

:tres de la ville européenne une large proportion d'indigènes. alheureusement les plans primitifs ont été modifiés, et on a bâti vers milieu de la vallée, en terrain marécageux, à 500 ou 600 mètres alement du bord du plateau.

En règle générale les routes et les tranchées qui les bordent sont rfaitement tenues. De même on jette au Congo les vieilles boîtes, :illes bouteilles, etc. Les milieux artificiels sont donc relativement u nombreux. Il faut pourtant faire exception pour les fossés, qui istent dans différentes parties de la ville et qui sont généralement al tenus, de même que pour les ordures qu'on jette derrière certains tels et certaines maisons particulières, et surtout pour le quartier digène, si dégoûtant, qui se trouve au nord-est du marché, et qu'on vrait abattre sans délai.

On devrait, au fur et à mesure, couper l'herbe qui pousse dans les rrains inoccupés de la ville, et cela pour deux raisons. D'abord le leil pourrait pénétrer jusqu'au sol et faire évaporer l'eau, qui, autre-ent, séjourne; ensuite, on empêcherait les nègres de s'en servir mme de latrines, et on éviterait ainsi, l'infection qui en résulte pour ville. Comme nous l'indiquons à la section XII, on peut rfaitement apprendre aux nègres l'usage des lieux d'aisances, et on devrait nullement tolérer ce qui se passe à l'heure actuelle.

Comme on le verra dans le cas de Lusambo, on pourrait fort bien ltiver des plantes de très petite croissance comme arachides ou tates douces dans les terrains ainsi déblayés. Les produits de la colte serviraient à la nourriture des ouvriers de l'État et des soldats.

2. FRÉQUENCE DE LA MALARIA.

On considère d'ordinaire Boma comme n'étant pas malsain* pour s Européens; mais comme nous n'avons pas pu nous procurer de atistiques médicales, il nous a été impossible de nous faire une idée :acte de la morbidité et de la mortalité par suite de malaria parmi s résidents.

Notre calcul reposera donc sur l' " Index endémique " obtenu par xamen du sang des enfants indigènes.

Nous donnons nos résultats dans le tableau ci-dessous:

* Le rapport de Bourguignon, Cornet, Dryepondt, Firket, Meuleman, indique une assez grande quantité de malaria en 1896-98.

INDEX DE MALARIA ENDÉMIQUE À BOMA, OCTOBRE, 1903.

Age des enfants examinés.	Nombre d'enfants examinés.	Nombre d'enfants atteints.	Index endémique.	Remarques.
0—5	18	18		Enfants de la Force Publique de Boma. Pas un n'avait plus de 4 ans; 3 avaient moins d'un an. (Tous les enfants du camp ont été examinés.)
5—10	—	—	100%	
10—x	—	—		
0—5	—	—		Garçons de la Colonie Scolaire de Boma.
0—10	32	22	70%	
10—x	18	13		

Il y avait donc " beaucoup de malaria " à Boma.

3. MOUSTIQUES VUS À BOMA ET LEURS MILIEUX DE REPRODUCTION.

On a observé à Boma un grand nombre d'espèces de moustiques appartenant aux trois genres suivants, *Anophelinæ*, *Culex*, et *Mansonia*.*

On trouvait qu'il y avait à Boma ou dans ses environs quatre espèces d'*Anophelinæ* le *Pyretophorus costalis*, le *Myzomyia funesta*, le *Cellia pharoensis* et le *Myzorhynchus mauritianus* dont les trois premiers peuvent transmettre la malaria. Nous avons disséqué treize *Pyretophorus costalis* est deux *Cellia pharoensis* en tout. Nous en avons trouvé deux d'infectés, une de chaque espèce.

Pour plus de simplicité, nous décrivons tout d'abord les milieux de reproduction déjà existants à l'époque de notre visite en Octobre, 1905. Nous mentionnons ensuite les endroits où pourraient se former, à la saison humide, des masses d'eau propres au développement des moustiques.

(1) " Herbe à hippopotame."

L'herbe (fig. 1) connue sous ce nom dans le pays, pousse au fond de l'eau et peut traverser une couche de liquide de 1·50 mètre et plus. Elle est d'ordinaire d'une végétation luxuriante et, à une certaine

* Dans les rapports qui suivent, nous n'avons donné le nom des espèces que lorsque c'était absolument nécessaire. En général, dans ces rapports, le genre suffira. Pour les détails on consultera utilement notre prochain rapport sur la distribution des moustiques dans l'État Indépendant du Congo.

distance, on peut facilement confondre avec la terre ferme ses enchevêtrements de feuilles et de tiges flottant à la surface de l'eau. Au sein de toute cette végétation, il y a naturellement un nombre infini de petites flaques d'eau, inaccessibles même aux plus petits poissons, et qui forment des milieux particulièrement favorables aux moustiques. C'est de là que viennent la plupart de ceux qui infestent Boma pendant la saison sèche.

Sur le plan nous indiquons par une croix les endroits où se trouvent les larves d'*Anophelina*, et par un cercle les endroits où l'on a aperçu des larves d'un autre genre. On verra d'un coup d'œil que les moustiques fraient partout dans la Rivière des Crocodiles, au moins jusqu'à l'endroit où nous l'avons examinée, ainsi que dans l' " herbe à hippopotame " du Congo. Nous n'avons examiné cette dernière qu'en un endroit.

(2) Marais des environs de Boma.

(*a*) Il y avait de l'eau stagnante, où se reproduisaient les *Anophelinæ* et les *Culex*, dans l'espace compris entre la rue de la Rivière, l'avenue de la Force Publique, l'avenue Royale et la rue de la Digue.

(*b*) Le marais qui se trouve immédiatement au sud du plateau, et le grand marécage des papyrus, qui est situé à l'est du plateau et des deux côtés de l'Avenue St.-Jean, étaient presque à sec au moment de notre visite. Nous n'y avons trouvé que quelques larves.

(3) Milieux de reproduction artificiels.

Il est inutile de répéter la liste des ustensiles, réservoirs, etc., où l'on trouve les larves. Nous l'avons donnée en détail dans la première partie de notre rapport, où nous traitons de la reproduction des moustiques.

Près de la prise d'eau il y a un endroit (voir le plan) où on avait fait un creux dans le sable, au bord de la Rivière des Crocodiles ; il était plein d'eau et fourmillait de larves de *Pyretophorus costalis*.

Il n'y a pas d'égouts et il n'y a que quelques fossés à ciel ouvert à Boma. L'écoulement des eaux de ménage et autres, dans beaucoup de maisons particulières et d'hôtels, se fait donc au moyen de courtes gouttières, qui vont se déverser sur le sol. Il se forme ainsi de petites flaques d'eau qui se remplissent continuellement et favorisent la reproduction du *Culex*.

Pendant la saison humide ces milieux de reproduction ne disparaîteront pas, et d'autres viendront encore s'y ajouter. Par exemple le terrain inoccupé qui se trouve autour des "Produits de Mayumbe," des deux côtés de l'Avenue de la Poste, est souvent inondé partiellement par la pluie. Un ou deux fossés à ciel ouvert, dans la ville basse, ont une pente très légère et un écoulement très irrégulier, et sont forcés de se remplir d'eau stagnante. Le petit marais au sud du plateau et le grand marais des papyrus, à l'est, seront, à la saison des pluies, de véritables nids à moustiques.

Il sera nécessaire de veiller au ravin qui se trouve entre le "plateau" et l'établissement du personnel blanc de la Force Publique.

4. RECOMMANDATIONS.

(1) Combler les Marais.

Il y a une petite colline au sud du Plateau. C'est là qu'on a pris, en grande partie, les matériaux employés pour combler les marais déjà reconquis. Il y reste encore amplement de quoi combler complétement ceux qui restent à l'ouest de la gare, et pour relever de 50 centimètres à un mètre le niveau des terres basses qui se trouvent dans le voisinage de la Place de la Marine et des Produits de Mayumbe.

Une grande partie du marais des papyrus est à un niveau inférieur à celui du Congo. Il est donc impossible de le draîner, et cela entraînerait un travail énorme de le reconquérir. C'est l'affaire des ingénieurs compétents de trouver le moyen le plus économique de le dessécher. Nous croyons, en attendant, qu'on rendra de grands services en coupant soigneusement l'herbe, de façon à permettre l'évaporation des eaux stagnantes et, aux endroits où elle ne se ferait pas, d'employer le pétrole de la manière décrite à la section iv.

On fera bien d'adopter pour le moment les mêmes mesures, dans le cas des marais qu'on se propose de combler à l'intérieur du poste.

(2) Enlever "l'Herbe à Hippopotame."

Il faut débarrasser de cette herbe les bords du fleuve et de la Rivière des Crocodiles. On devra veiller à ce qu'il ne se forme de flaques d'eau, ni sur l'une ni sur l'autre rive de la Rivière des Crocodiles, même à la saison des eaux basses.

Il y a, à Boma, beaucoup de petits poissons* qui vivent de larves

* Entre autres l'*Haplochilus Singa ;* décrit et nommé par le Dr. C. A. Boulanger, Ann. Mus. Congo, p. 113, pl. 47, Fig. 1, 1899.

de moustiques. Si on les laisse pénétrer partout dans la Rivière des Crocodiles, elle ne produira plus de moustiques.

(3) Séparation des Races.

Comme nous l'avons dit plus haut, Boma est appelée à se développer. On devrait réserver un grand espace de terrain aux Européens, et on ne devrait y permettre la constrúction d'aucune habitation nègre. Il y a suffisamment de terrain au nord-est de Boma, pour y fonder un village de " boys," et on peut aisément construire un nouveau camp pour les soldats, à une distance convenable (5 à 800 mètres) de l'espace réservé à la ville européenne. La résidence actuelle des fonctionnaires de la Force Publique les expose, peut-être plus qu'aucun autre groupe de fonctionnaires, aux atteintes de la malaria. La Colonie Scolaire est également trop près du quartier européen, qui se trouve sur le Plateau. Mais, comme il y a un espace de 250 mètres entre elle et le bord de ce dernier, il n'est pas absolument nécessaire de l'éloigner immédiatement.

Une des premières mesures à prendre, serait d'abbatre les cases indigènes qui se trouvent près du Marché, et d'en transporter les habitants sur un nouveau site, en dehors du quartier européen. On devrait faire en même temps tous les efforts possibles pour y détruire les moustiques, ainsi que dans la ville européenne. Les mesures générales de santé publique dans ces nouveaux villages indigènes seraient sous la direction du service de santé publique de Boma.

(4) Mesures générales.

Combler les petites mares de la presqu'île qui se trouve à l'embouchure de la Rivière des Crocodiles, et tenir en état de propreté les fossés qui bordent les rues. Jusqu'à l'achèvement des travaux dans les marais il faudra avoir recours au pétrole pour la destruction des moustiques à Boma. Les équipes préposées devront être particulièrement vigilantes pendant la saison des pluies. Chaque nouvelle averse peut en effet créer de nouvelles flaques, ou, plus souvent encore, enlever le pétrole dans celles qui ont déjà été traitées.

On nous a dit, qu'on se proposait de pratiquer sous peu des égoûts souterrains dans la ville basse. Ils auront pour but l'écoulement de l'eau des pluies dans le Congo. A notre avis, pareille entreprise serait une erreur à l'heure actuelle. La différence de niveau entre les hautes eaux du fleuve et les tuyaux, d'égout, disons à l'intersection de la rue

des Marais et de l'Avenue de la Poste, serait tellement faible, qu'il serait presque impossible d'assurer un écoulement régulier. Il se formera donc, à l'intérieur des tuyaux, des inégalités, où l'eau s'accumulera et où les moustiques pourront se reproduire. Nous recommanderions, de préférence, des tranchées à ciel ouvert, revêtues de ciment. On pourrait établir ainsi une plus forte pente, et on aurait toujours l'avantage de voir ce qui s'y passe. Il serait bon aussi de laisser de côté l'installation des égouts souterrains, jusqu'à ce qu'on ait relevé le niveau des terres basses qui se trouvent dans le voisinage de la place de la Marine et des Produits de Mayumbe.

Rapport sur Matadi.

Comme nous n'avons fait qu'un examen rapide de Matadi, notre rapport sera moins circonstancié que dans le cas des autres postes.

Matadi est le point extrême de la navigation fluviale du bas Congo pour les steamers venus de l'Océan, et c'est en même temps le terminus du chemin de fer qui le relie à la partie navigable du Congo supérieur. L'avenir commercial de Matadi est donc assuré et, puisque ce doit être une ville de commerce importante, il est de toute nécessité d'en assurer la salubrité.

Nous pensons que l'emplacement de la ville a été mal choisi et que les maisons des Européens, pour le moins, devraient être construites sur le plateau, et non sur le flanc de la colline, comme c'est le cas à présent. Mais même dans l'état actuel des choses, il ne serait pas bien difficile de débarrasser la ville de ses moustiques. Matadi est bâtie sur un terrain rocheux et, pendant la saison humide, elle est traversée par deux ou trois ruisseaux de nature torrentielle. Les moustiques ne sauraient manquer de se multiplier aux endroits où ces cours d'eau s'étendent en nappes tranquilles. Avec les anfractuosités où l'eau de pluie s'amoncelle dans les rochers, ce sont à peu près les seuls milieux de reproduction favorables de la ville haute. Dans le quartier indigène, le " Sancel," il y a dans presque toutes les maisons des réservoirs où peuvent se développer les moustiques.

Au bord du fleuve les moustiques élisent domicile dans les vieilles allèges échouées sur la berge, ou dans les péniches à l'ancre. Les champs d' " herbe à hippopotame " au bord du fleuve leur offrent aussi

un asile assuré. La baie qui se trouve en face de l'American Baptist Missionary Union, et celle qui avoisine la Maison Hollandaise, sont des endroits particulièrement dangereux.

La malaria n'est pas rare parmi les Européens à Matadi. L'Index endémique est particulièrement élevé, comme le montre le tableau ci-dessous.

INDEX ENDÉMIQUE DE MATADI
(Nov., 1903).

Age donné en **années.**	Nombre d'enfants **examinés.**	Nombre d'enfants **atteints.**	Proportion des enfants **atteints.**	Remarques.
0—5	9	3		**Enfants de la Force Publique.**
5—10	1	—	33%	**Aucun des enfants examinés n'avait moins d'un an; un enfant de six mois a été examiné et reconnu**
10—x	—	—		**atteint.**
0—5	16	15		**Enfants du village des Travailleurs du Chemin de Fer.**
5—10	4	4	95%	**3 enfants de moins d'un an ont été examinés, dont deux étaient atteints. Parmi les sujets atteints,**
10—x	7	2		**il y avait un jeune garçon d'au moins 15 ans.**

On a capturé deux espèces d'*Anophelinæ* à Matadi dans les maisons d'Européens et dans les cases des soldats indigènes. Ce sont le *Pyretophorus costalis* et le *Myzomyia funesta*, chacun peut transmettre la malaria.

Nos recommandations pour Matadi se borneront aux points suivants :—

(1) Débarrasser de toute végétation le bord du fleuve et les cours d'eau du voisinage de Matadi.

(2) Régulariser le cours des torrents de Matadi de façon à empêcher l'eau de s'étendre en nappes.

(3) Surveiller les milieux de reproduction connus, ainsi que les creux de rocher, où s'amoncelle l'eau de pluie ; et, suivant les besoins, les combler, les vider, où les traiter par le pétrole.

(4) Veiller à ce que l'élément indigène et l'élément Européen soient encore plus complétement séparés qu'ils ne le sont déjà. En particulier, éloigner du quartier européen les baraquements des soldats et le camp de la police, qui est situé juste en face de l'entrée de l'American Baptist Missionary Union.

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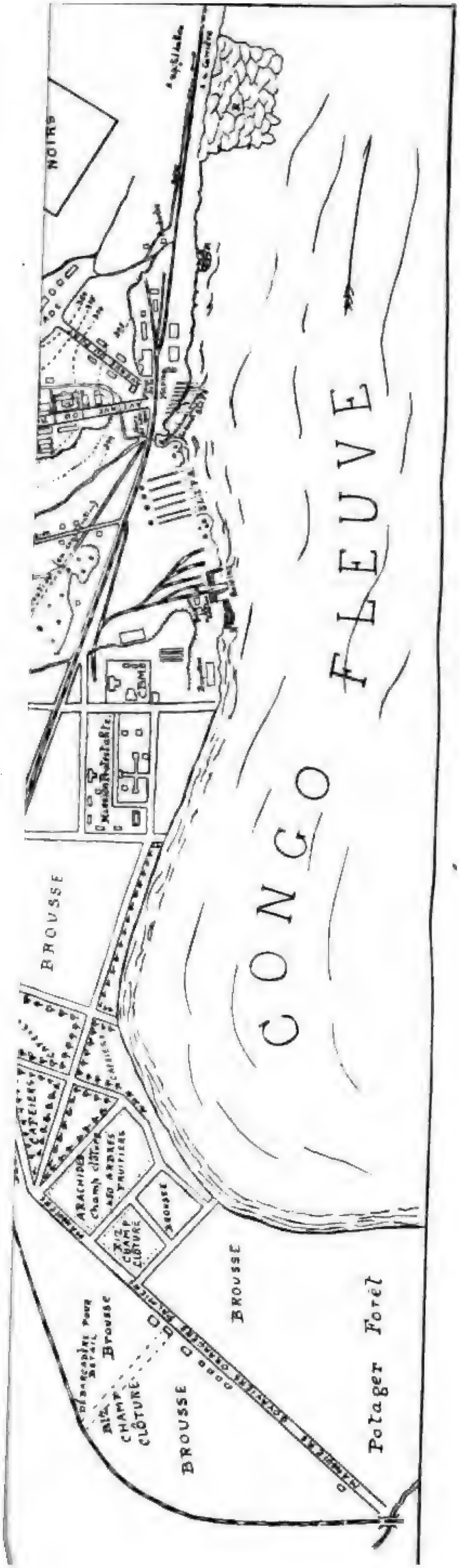


Rapport sur Léopoldville.

1. SITUATION ET ENTRETIEN DU POSTE.

Léopoldville est le principal poste du district de Stanley Pool. La ville est bâtie sur la rive méridionale du Congo à la limite de la partie navigable du fleuve supérieur du côté de la mer. Les rapides commencent juste au-dessous de la station et continuent presque sans interruption jusqu'à Matadi, où s'arrête la navigation du Congo.

Léopoldville est le point terminus de la voie ferrée qui relie le haut Congo au bas Congo. C'est également le port d'attache des "steamers" fluviaux de l'Etat Indépendant du Congo. C'est par là que se font tous les transports pour le gouvernement entre la mer et les stations de l'intérieur. C'est donc un poste important et où règne une très grande activité. La population est d'environ 250 Européens et de 3,000 Africains.* Il y a d'abord les fonctionnaires européens ordinaires, qui sont employés dans les différentes branches de l'administration et qu'on trouve dans tous les postes de l'Etat Indépendant. Il y a en outre un nombreux personnel de mécaniciens et d'artisans occupés à la construction et à la réparation des "steamers" fluviaux au percement des bassins et autres travaux publics. On emploie surtout des indigènes, soit dans les travaux publics comme ouvriers, soit dans le service des transports comme "matelots" ou comme "débardeurs." Un petit corps de soldats indigènes est en outre cantonné à Léopoldville. Le reste de la population indigène se compose de "boys" ou domestiques d'Européens, d'ouvriers des maisons de commerce et de quelques traitants indigènes. La grande majorité des habitants de Léopoldville est dons sous le contrôle direct du gouvernement de l'Etat Indépendant et occupe le quartier ouest de la ville, tandis que les maisons de commerce forment un second groupe plus petit à environ 500 mètres du quartier gouvernemental. Le camp des "Travailleurs Beach" et celui des "Travailleurs de la Côte" qui sont indiqués sur le plan dans la partie est de la ville, où ils se trouvaient en 1903, ont été transférés depuis auprès du camp des "Travailleurs de la Station" et des "Travaux publics." Cette disposition rend évidemment l'administration beaucoup plus

* Ces chiffres ne sont qu'approximatifs. A Léopoldville comme ailleurs il a été impossible d'obtenir de chiffres exacts sur le mouvement de la population et sur la fréquence des maladies.

facile, les mesures sanitaires pouvant toujours se prendre plus aisément en territoire public qu'en propriété particulière.

Comme le montre le plan que nous donnons, Léopoldville est bâtie sur une baie formée par le fleuve. Les maisons de commerce et les missions protestantes sont à l'extrêmité orientale de la baie et la ville officielle à l'ouest; au milieu, et à quelque distance du bord de l'eau s'élève la mission catholique; les maisons qui forment ces trois groupes sont bâties sur un terrain sec et élevé. L'espace compris entre eux et le fleuve était très marécageux autrefois. On le comble graduellement depuis 10 ans et à présent une grande partie en est occupée par des lignes de chemin de fer, des bassins, des "slips," des magasins et des résidences d'Européens. Comme on le voit par les indications données sur le plan, on propose de ne laisser du marais que l'espace nécéssaire à un canal d'écoulement rapide, par où puissent se déverser dans le Congo les quatre ruisseaux qui traversent Léopoldville.

Le quartier Européen de la ville officielle est construit sur le flanc est d'une éminence de 374 mètres appelée le Mont Léopold. L'emplacement du quartier des ouvriers et des soldats indigènes a été choisi plus loin dans les terres sur un plateau sablonneux et à une plus grande altitude que le quartier européen.

Le sol sur lequel Léopoldville est construite se compose en règle générale d'une argile très sablonneuse ou d'une terre légère. Il est poreux et dans presque toute la ville les flaques d'eau de pluie s'infiltrent rapidement. On peut assurer une pente excellente pour les tranchées à ciel ouvert dans toutes les parties du poste. Le problème de l'écoulement des eaux de pluie à la surface devrait donc être relativement facile.

Les saisons sont assez irrégulières à Léopoldville. Il peut tomber de l'eau pendant tous les mois de l'année. Il y a pourtant une "saison sèche" bien déterminée et pendant laquelle, à proprement parler, il ne pleut pas; elle s'étend de la mi-juin environ jusqu' au 1er septembre. Pendant la saison humide la chute des pluies est abondante et il y a beaucoup d'orages, souvent 2 ou 3 en vingt-quatre heures.

On s'est donné beaucoup de peine pour construire la ville et en améliorer le site et on a mûrement étudié les méthodes à employer. On peut dire que le résultat général obtenu est excellent; l'Avenue du Roi Souverain et un grand nombre des bâtiments qui la bordent

ont été admirablement construits. Au point de vue de l'hygiène, les travaux faits au bord du fleuve méritent les plus grands éloges.

Léopoldville a été bâtie sur un plan bien défini dans lequel on a prévu son développement futur. En modifiant légèrement ce plan pour les besoins de l'hygiène tropicale, on pourra faire de Léopoldville une ville modèle à tous égards pour la région des tropiques. L'emplacement offre déjà par lui-même de nombreux avantages naturels et les améliorations qu'on y a apportées en ont encore ajouté d'autres. Mais il y a encore beaucoup à faire pour satisfaire les besoins de l'hygiène tropicale.

2. FRÉQUENCE DE LA MALARIA.

On ne considère pas Léopoldville comme un poste particulièrement malsain. Les fièvres paludéennes y sont pourtant communes et il y a tous les ans un ou deux cas d'hémoglobinurie parmi les résidents européens.

Nous avons examiné le sang tiré du doigt des enfants dans deux quartiers du poste et nous avons obtenu les résultats suivants :

MALARIA ENDÉMIQUE À LÉOPOLDVILLE
(Mai, 1904).

Age.	Nombre de cas examinés.	Nombre de cas d'Infection.	Poucentage.	Remarques.
0 - 5	29	25		Enfants du Camp des Soldats. 5 enfants de noirs d'un an ont été examinés, 4 étaient atteints.
5—10	4	4	87%	
10 -x	—	—		
0—5	26	20		Enfants du camp des travailleurs de N'Galiéma.
5—10	—	—	77%	
10—x	—	—		

L'index de la malaria endémique est donc manifestement élevé à Léopoldville.

3. ANOPHELINÆ PRÉSENTS À LÉOPOLDVILLE.

En fait d'*anophelinæ* à Léopoldville nous avons capturé des *Pyretophorus costalis*, des *Myzorhynchus paludis* et des *Myzorhynchus mauritianus* dont le premier peut transmettre la malaria.

Nous avons déjà vu que l'Index de la malaria endémique à Léopoldville était élevé. Il est donc curieux que sur 92 *Pyretophorus costalis* que nous avons attrapés dans les cases des indigènes et disséqués à Léopoldville au mois de juin, pas un n'ait été infecté.

A proprement parler, on a trouvé des *Anophelinæ* dans les maisons d'européens et d'indigènes dans presque toutes les parties de la ville. C'est bien d'ailleurs à quoi nous nous attendions par suite du grand nombre de milieux de reproduction qui avoisinent le poste. On a trouvé un grand nombre de *Pyretophorus costalis* cachés pendant la journée sous les tables du "mess." Leur présence constitue un grave danger pour ceux qui y prennent leurs repas. Tous les agents de l'Etat sont tenus d'y venir manger, sauf les hauts fonctionnaires et les malades. Il n'est pas rare d'y voir à l'heure des repas des personnes atteintes de malaria, tant résidents du poste que malades venus du Congo supérieur et en route pour la côte. Les *Anophelinæ* ont ainsi toutes les chances possibles de contracter la malaria et de la transmettre ensuite à des personnes encore indemnes.

4. MILIEUX DE REPRODUCTION DES MOUSTIQUES À LÉOPOLDVILLE.

Les observations sur lesquelles repose cette partie de notre rapport ont été faites pendant deux examens du poste de Léopoldville. Le premier et de beaucoup le plus complet a été fait en novembre-décembre 1903, le deuxième en juillet 1905.

Pour plus de facilité nous avons divisé, comme d'habitude, les milieux de reproduction en deux groupes (1) les milieux de reproduction permanents et (2) ceux qui ne sont dangereux qu'après des chutes d'eau continues.

(1) Milieux de reproduction permanents.

Nous avons déjà dit que les moustiques ne se reproduisaient pas dans les eaux courantes des grands cours d'eau. Ce n'est que le long des rives, dans les baies et les endroits abrités qu'ils se développent.

Le bord du fleuve à Léopoldville est en général occupé par des bassins, ou des "slips," ou bien il est de nature rocheuse et sans

FIG. 1, HERBE À HIPPOPOTAME.

FIG. 2, MARAIS À REMBLAYER, LÉOPOLDVILLE, 1905

végétation et n'offre par conséquent que peu d'endroits propres à la reproduction des moustiques.

Entre la station de la mission protestante et les " bungalows "* du Chemin de Fer des Grands Lacs il y a une petite étendue d'herbe à hippopotame (fig. 1) qui est un milieu de reproduction dangereux au moment des hautes eaux. Les conditions étaient les mêmes le long de la berge à l'ouest de la poudrière et à l'embouchure du canal de dérivation.

A l'époque des basses eaux, le fleuve, en abaissant son niveau laisse des flaques d'eau dans les inégalités que présente le fond argileux des bassins qui se trouvent en face des bungalows du Chemin de Fer des Grands Lacs.

Il s'y reproduit des quantités énormes d'*anophelinæ*. Dans le bassin le plus à l'est, une petite source alimente constamment ces flaques d'eau. L'eau s'accumule souvent dans les empreintes de pas et autres dépressions de la surface argileuse du sol, entre les bassins et l'embouchure du canal de dérivation.

Au moment des basses eaux le fleuve laisse de l'eau dans les rochers qui se trouvent le long de la berge à l'ouest du poste et les moustiques peuvent s'y reproduire.

Comme nous l'avons dit plus haut, on a partiellement comblé le marais qui se trouve au sud de la ligne de chemin de fer (voir plan). Mais il se reproduit un grand nombre de moustiques de toutes sortes dans la partie restante. Comme nous l'avons indiqué sur le plan, on a percé un canal de drainage à travers le marais pour faciliter l'écoulement des eaux apportées par les deux ruisseaux qui passent des deux côtés de l'établissement du C.C.B.C. Il n'y avait pas de larves dans les eaux courantes du canal ni dans les ruisseaux qui l'alimentent. Le courant était rapide et le poisson abondant. C'est le long des bords couverts d'herbes des grandes mares (voir fig. 2) et dans l'eau tranquille des petites flaques d'eau du marais que les larves de moustique pullulaient.

Sur le plan nous donnons comme marais un espace de terrain situé au sud de la ligne du chemin de fer. Une partie de ce terrain est en réalité à un niveau relativement élevé. Il s'y trouve cependant des

* Maison composée d'ordinaire d'un simple rez-de-chaussée et entourée d'une verandah.

parties qui sont plus basses que les autres et un certain nombre de petites excavations où l'eau s'amoncelle après la pluie.

Dans certaines parties du marais et en quelques endroits où les ruisseaux font des courbes brusques, l'herbe était si épaisse qu'on ne voyait plus l'eau. On y a souvent trouvé de larves d'*anophelinæ*.

Il arrive fréquemment que les indigènes pour attraper du poisson, barrent les rivières qui se jettent dans le marais, en particulier celle qui passe à l'est du C.C.B.C., ou en détournent le courant. Il s'est ainsi formé un grand nombre de flaques d'eau tranquille et d'irrégularités de terrain dans le lit des ruisseaux, et on y a trouvé des larves de moustiques.

A partir de l'endroit qu'on appelle la Source (voir le plan) il y a un ruisseau qui se jette dans le canal de dérivation près de son embouchure. Pendant les 150 premiers mètres de sa course il est bordé par un terrain bas, marécageux et parsemé de flaques d'eau. Les moustiques peuvent s'y reproduire. Au milieu de son cours les berges sont un peu plus élevées et recouvertes de broussailles tellement épaisses, qu'il a été impossible de l'examiner convenablement. En un point nous l'avons examiné rapidement, sans y trouver de larves. A partir de l'endroit où la rue des Jacquiers le traverse jusqu'à son embouchure, les berges sont soutenues par une série de pieux en bambou et le courant est tout droit et assez rapide. Néanmoins les débris et les saletés qu'on a souvent le tort d'y jeter, viennent quelquefois ralentir la marche de l'eau, qui devient ainsi en certains endroits assez lente pour que les *anophelinæ* puissent s'y reproduire.

Juste derrière le mess (voir le plan) il y a une petite source qui jaillit à la surface de sol. Un petit ruisseau en descend pour aller se jeter ensuite dans le canal de dérivation à son embouchure. Les eaux de pluie qui viennent du versant oriental du Mont Léopold le creusent encore quand il y a eu de fortes averses. Ce petit ruisseau est en contre-bas de l'Avenue du Roi Souverain et se trouve juste derrière les résidences européenes, du côté occidental de l'avenue. Il traverse une sorte de terre légère et molle et il en résulte que son lit est irrégulier et souvent obstrué par la végétation. On y fait également écouler les eaux résiduaires du mess et des résidences européennes et comme le canal ainsi formé est très insuffisant, il en résulte un état de choses absolument mauvais. On y a souvent trouvé des larves de moustiques. En décembre 1903 les *anophelinæ* se reproduisaient en toute liberté,

FIG. 3. REMBLAYAGE DES MARAIS.

FIG. 4. EXCAVATION ET DÉCHETS PRÈS DU 'MESS.'

juste au-dessous du mess, dans un petit espace de terrain marécageux qui communiquait avec ce ruisseau.

(2) Milieux de reproduction présentant du danger après une série continue de chutes d'eau.

Quelques-uns de ces milieux de reproduction ont déjà été indiqués dans la section précédente. Nous indiquerons en outre les points suivants.

Une grande partie du terrain reconquis (Fig. 3) qui se trouve le long de la ligne de chemin de fer, présente une surface argileuse. L'eau de pluie y séjourne quelquefois pendant plusieurs jours et forme des flaques d'eau où l'on a souvent vu fourmiller les larves d'*anophelinæ*.

A l'intérieur de la station on a jeté de vieilles boîtes et des débris de toutes sortes autour des établissements de commerce, derrière le mess et en différents autres endroits. On y a trouvé des moustiques qui s'y reproduisaient ; de même dans les réservoirs qui se trouvent dans les locaux des particuliers.

A " La Carrière," à l'ouest du poste, on extrait continuellement du sol de grosses pierres destinées à la construction des maisons. On ne bouche pas les trous ainsi formés ; il s' y accumule de l'eau pendant la saison des pluies et il s'y reproduit des *anophelinæ*. Il y a en outre une ou deux petites excavations dans la station, une derrière la maison du Directeur et une autre derrière le mess (fig. 4) où l'eau s'amoncelle pendant la saison des pluies.

5. RECOMMANDATIONS.

On fera bien de combler aussi rapidement que possible ce qui reste du marais au sud de la ligne de chemin de fer. Tant que cela ne sera pas fait et que l'écoulement rapide des ruisseaux ne sera pas assuré par l'établissement d'un chenal escarpé où les moustiques ne puissent pas se reproduire, les maisons qu'on a récemment bâties au bas de l'avenue de la mission catholique, ne sauraient manquer d'être infestées par les *anophelinæ*.

On fera bien également de redresser le cours de tous les ruisseaux et de les débarrasser de la végétation qui les encombre. On pourrait aisément drainer le terrain marécageux qui avoisine " La Source " en y perçant des tranchées convenables. On devrait transformer en

jardin potager pour le mess tout le terrain couvert de broussailles qui se trouve des deux côtés du ruisseau qui descend de " la Source."

Pendant la saison des fortes pluies d'énormes quantités d'eau descendent par les deux ruisseaux qui viennent de " la Source " et de derrière le mess. Le terrain qu'ils traversent, particulièrement celui qui vient du mess, est mou. Il en résulte souvent que leurs berges sont emportées par la force du courant ; ils ont alors un lit irrégulier et il s'y forme des flaques d'eau tranquilles où se reproduisent les moustiques. On devrait redresser le cours de ces ruisseaux, en aplanir le lit et renforcer les berges avec des matériaux capables de résister à l'assaut des crues pendant la saison humide.

Quand on aura pris toutes les mesures que nous venons d'indiquer, il suffira d'une petite équipe pour traiter les milieux de reproduction restants.

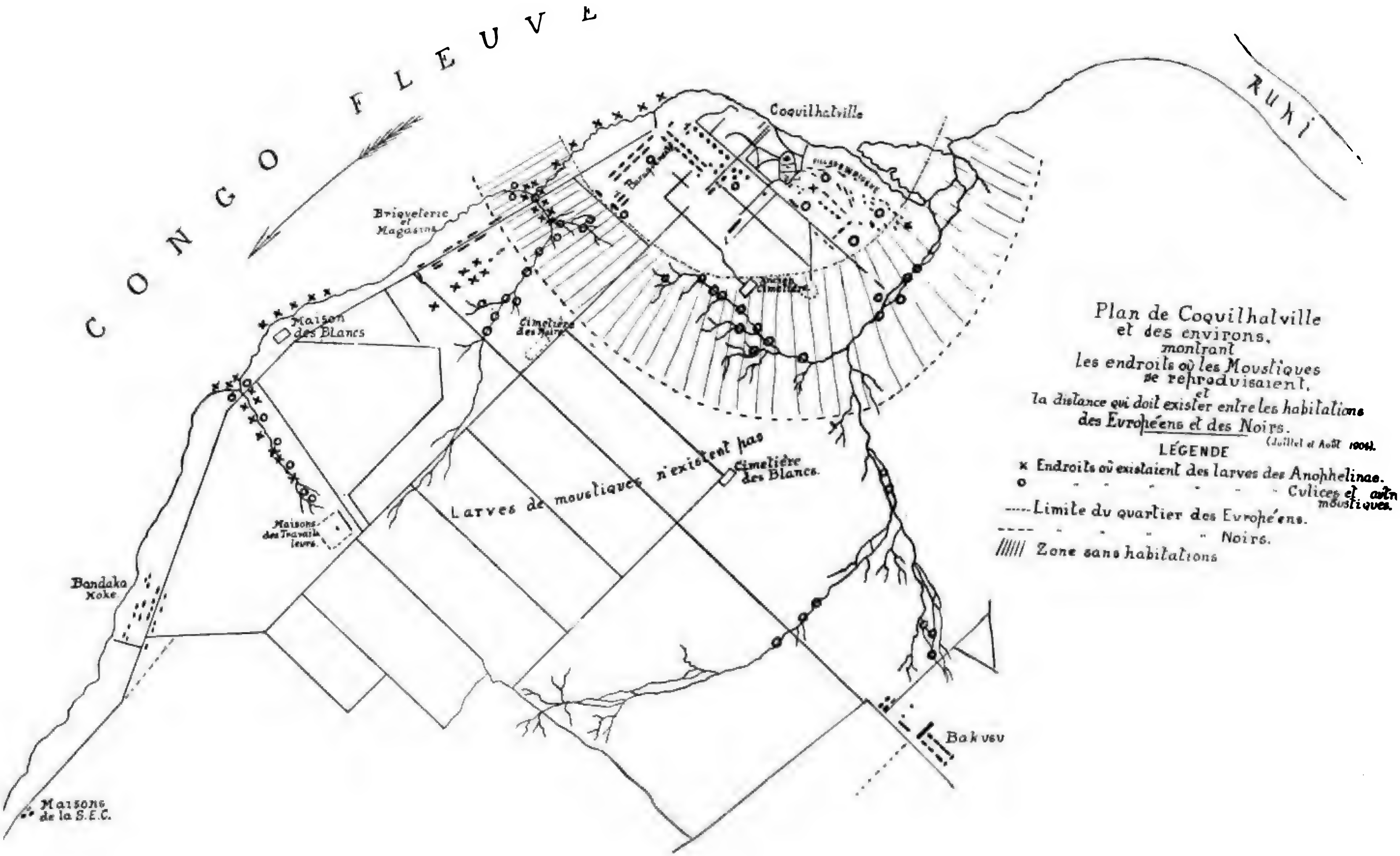
Léopoldville est déjà partiellement divisée en quartier african et en quartier européen. Au point de vue de la prophylaxie de la malaria le séparation devrait être encore plus complète. On devrait abattre les hangars élevés derrière le mess pour les voyageurs indigènes. A présent l'hôpital des Européens, la Croix-Rouge, est, on peut dire, entouré de deux côtés de maisons d'indigènes, qui n'en sont éloignées que de 100 mètres.

Dans les plans que l'on fera pour le développement de Léopoldville, on devrait réserver un espace de 400 à 1,000 mètres entre la ville européenne et la ville nègre.

Il y a encore un ou deux points concernant les conditions sanitaires générales de la ville qui méritent mention : D'abord quelques-unes des maisons où habitent les Européens sont en très mauvais état.

Ensuite on jette, sans plus de façon, des détritus de toutes sortes sur le flanc de la colline qui se trouve derrière la maison de l'Intendant et sur les bords du ruisseau qui vient de la " Source " juste à partir de l'endroit où il est coupé par la rue des Jacquiers.

Enfin, à Léopoldville comme dans les autres postes de l'Etat Indépendant, les nègres font leurs déjections à peu près n'importe où, sans qu'on les en empêche. A certains endroits du poste il est à peu près impossible de marcher au bord des sentiers, tant il y fait malpropre. Les endroits les plus repoussants peut-être sont celui où l'avenue des Jacquiers traverse le petit ruisseau de la Source et un coin recouvert de broussailles qui se trouve au sud le l'Avenue du



Plan de Coquilhalville
et des environs,
montrant
les endroits où les Moustiques se reproduisaient,
et
la distance qui doit exister entre les habitations des Européens et des Noirs.
(Juillet et Août 1904).
LÉGENDE
× Endroits où existaient des larves des Anophelinae.
o - - - - - - Culices et autres moustiques.
----Limite du quartier des Européens.
---- " " " " Noirs.
////// Zone sans habitations
CONGO FLEUVE
RUKI
Coquilhatville
Briqueterie et Magasins
Maison des Blancs
Cimetière des Noirs
Cimetière des Blancs
Larves de moustiques n'existent pas
Maisons des Travailleurs.
Bandaka Xoke
Maisons de la S.E.C.
Bakusu

Port, juste derrière la maison du Directeur Général. On n'a pas construit de latrines publiques pour les nouveaux camps de travailleurs sur le plateau. L'établissement immédiat d'un système convenable pour l'enlèvement de ces immondices est un des besoins qui se font le plus sentir à Léopoldville. Comme nous le disons à la section XII, il est difficile de décider quel serait le meilleur système.

Il y a environ 2,000 nègres au service du gouvernement à Léopildville. L'hôpital qui leur est réservé est, à notre sens, tout à fait insuffisant.

Rapport sur Coquilhatville.*

1. SITUATION ET ENTRETIEN DU POSTE.

Les maisons européennes de Coquilhatville sont situées sur une élévation, qui se trouve au confluent du Ruki et du Congo. Cette élévation couvre une assez petite étendue de terrain et descend rapidement de tous les côtés, soit vers des marécages, soit vers des cours d'eau.

Le sol se compose d'argile sablonneuse. Il est presque imperméable, et l'eau de pluie forme des flaques qui mettent un temps assez long à s'infiltrer dans les terres.

Coquilhatville est presque à l'équateur ; il s'ensuit qu'il n'y a pas de changements marqués dans les saisons. Il y pleut à toutes les époques de l'année, particulièrement en novembre et en décembre. La température est constamment élevée, et il peut même faire très chaud pendant les quatre premiers mois de l'année. Le climat et les environs du poste sont donc admirablement adaptés à la reproduction des moustiques.

Le poste est tenu dans un grand état de propreté, et, s'il n'en était pas ainsi on y verrait encore plus de moustiques qu'il n'y en a à présent.

Le grand défaut du poste, c'est la proximité des cases, des baraquements des soldats et d'un village d'indigènes.

2. FRÉQUENCE DE LA MALARIA.

Nous n'avons pas établi l'Index endémique à Coquilhatville ; mais il y est probablement tout aussi élevé que dans les autres postes congolais, où le calcul a été fait.

* Les conclusions contenues dans ce rapport ont déjà été exprimées dans une lettre, que nous avons envoyée le 14 août 1904 à Mr. le Haut Commissaire Royal Malfeyt.

Ici comme ailleurs, il n'y avait pas de statistiques médicales. Le Dr. Angela, l'officier médical résident, faisait cette constatation, que les Européens nouvellement arrivés avaient tous invariablement tôt ou tard une attaque de malaria et que les rechutes étaient nombreuses. Il citait en particulier une maison où deux Européens étaient morts de la malaria pendant son séjour à Coquilhatville. Un troisième, qui habitait la même maison, avait été rapatrié pour la même maladie. La maison se trouve à côté de la briqueterie comme on le verra sur le plan, et était placée au meilleur endroit pour contracter la malaria. Tout près, il y avait des milieux importants de reproduction de l'*Anophelina*. Tout autour, s'élevaient des cases, et, en particulier, les hangars où l'on fait coucher les passagers indigènes des "steamers" fluviaux. Ces "steamers," en effet, ne voyagent pas la nuit. On fait escale tous les jours au coucher du soleil, et on envoie coucher à terre les passagers indigènes sous des hangars élevés à cet effet.

3. MOUSTIQUES VUS À COLQUILHATVILLE; LEURS FOYERS DE REPRODUCTION.

Dans le plan de Coquilhatville nous avons marqué d'une croix, les endroits où se reproduisent les *Anophelinæ*, et d'un cercle, les foyers de reproduction des autres moustiques.

On a trouvé des *Anophelinæ* se reproduisant dans le village indigène, qui est à 60 ou 80 mètres de la maison du Commissaire du District. Ils s'y reproduisaient, comme à la briqueterie, dans les trous qu'on avait faits pour extraire l'argile.

Juste au coucher du soleil, et pendant environ une heure après, il y a un petit *Anophelina*, le *Pyretophorus costalis* qui pénétre dans les maisons des blancs et des noirs de Coquilhatville. Un grand nombre de ces moustiques furent attrapés dans notre propre maison, et dans les excellents pièges que formaient les moustiquaires non réparés des soldats indigènes. Cette espèce ne piquait que le soir et le matin de bonne heure. Une heure après le lever du soleil, on n'en trouvait pas un dans les maisons, si ce n'est peut-être un insecte égaré, qui s'était pris dans un moustiquaire. Il est rare que ce petit insecte soit aperçu de celui dont il suce le sang. Il attaque d'ordinaire les poignets et les chevilles, qui ne sont pas suffisamment protégés, et en général les parties du corps sur lesquelles frottent les vêtements comme, par exemple, les genoux. Il produit un bruit à peine perceptible dans son

vol, et, même quand on est sur ses gardes, on peut se faire mordre souvent, avant de reconnaître sa présence. Ces *Anophelinæ* se reproduisent pour la plupart dans les petites baies que forme le Congo, (voir le plan); le courant n'y est pas fort et les grandes herbes mettent les larves à l'abri des attaques des petits poissons. Les conditions sont les mêmes et les moustiques se reproduisent de la même manière au confluent des petites rivières et du Congo.

Telles sont les habitudes du moustique, qui est probablement responsable de 90% des cas de malaria constatés sur les blancs à Coquilhatville.

Comme nous l'avons remarqué plus haut, le poste est si bien tenu, qu'on n'y voit aucune de ces flaques d'eau où, ailleurs, se reproduisent les " moustiques domestiques." Il n'y a que quelques inégalités dans les tranchées de drainage et dans les " compounds," où l'eau puisse séjourner. On a eu soin d'empêcher l'accumulation des pots creux, bidons, calebasses et autres ustensiles hors d'usage. Cependant on a retrouvé dans le quartier des soldats, une vieille baignoire, le revêtement en fer-blanc d'une caisse et une vieille jarre en argile, pleins de larves de *Culex*.

Quelques individus seulement du genre *Stegomyia* ont été vus dans le poste et on n'a trouvé aucun des endroits où ils se reproduisaient. Les *Mansonia*, un autre genre de moustiques, étaient très communs à Coquilhatville. Ils se reproduisent en très grand nombre dans les marécages couverts d'herbe et de bois, qui se trouvent autour du poste.

A la saison des pluies, les *Culex* se reproduiront certainement en très grand nombre dans les trous où l'on a tiré l'argile nécéssaire à la fabrication de la brique. On emploie un grand nombre de ces trous, pour y jeter toutes sortes de débris animaux et végétaux. Nous en avons en particulier examiné un, qui se trouvait dans le village voisin de la maison du Commissaire du district. Il avait environ un mètre de diamètre. L'eau qui y séjournait était complétement recouverte de feuilles et d'herbes, qui empêchaient l'évaporation et fourmillait de larves de moustiques. Les principes les plus élémentaires d'hygiène condamnent un pareil état de choses.

5. RECOMMANDATIONS.

Il serait impossible de faire disparaître d'une façon complète toute l'eau favorable à la reproduction des moustiques dans un rayon de 800 mètres de Coquilhatville. La destruction des moustiques ne se recommande donc pas comme la principale mesure prophylactique de le malaria à Coquilhatville.

1. Le premier point devrait être **la séparation des races,** c'est à dire que le quartier nègre devrait être reporté aussi loin que possible de celui des blancs. Comme on le verra sur le plan, on devrait réserver entre les deux quartiers, une zone où l'on ne construirait pas de maisons. On pourrait y planter un rideau d'arbres, qui arrêterait de façon excellente le vol des moustiques qui pourraient venir des cases indigènes.

A cet égard l'avenue de bambous qui suit la route, au-dessous des baraquements, est excellente de tout point. A Coquilhatville, le principe de l'isolement des races demanderait qu'on transportât à un autre endroit la ville indigène qui avoisine la maison du Commissaire, ainsi que le quartier des soldats et des " boys " et l'hôpital indigène.

Il est certain que, dans un avenir rapproché, le développement de la ville européenne exigera un emplacement plus considérable. Le site occupé à présent par le quartier des soldats ferait mieux l'affaire.

2. **La destruction des moustiques** dans les limites du poste ne serait qu'une mesure subsidiairie.

Bien que les moustiques soient appelés à venir continuellement dans la ville des foyers de reproduction qui l'entourent, les mesures que nous indiquons en diminueront considérablement le nombre dans le poste et y réduiront ainsi les chances d'infection.

Comme nous l'avons dit plus haut, on a déjà beaucoup fait à cet égard à Coquilhatville. Les rues sont larges et d'ordinaire unies et bien entretenues ; les fossés sont en bon état et l'écoulement s'y fait sans obstruction ; on coupe l'herbe régulièrement et on ne laisse pas pousser de broussailles ; on voit rarement de vieilles bouteilles. Ces efforts sont dignes de tout éloge, et il importe qu'on ne se relâche pas dans l'accomplissement de la tâche qui a été entreprise. En outre on fera bien de supprimer les foyers de reproduction suivants par les méthodes indiquées.

(*a*) LA RIVIÈRE : Toute la partie de la rivière qui s'étend de la

briqueterie jusqu'au delà de la maison du Commissaire, devrait être scrupuleusement débarrassée des longues herbes et des broussailles. L'herbe, comme nous l'avons déjà dit, empêche le menu fretin de pénétrer jusqu'aux larves des moustiques.

(*b*) LES MARÉCAGES : Ils sont de deux sortes : le marais couvent d'herbe qui va de l'embouchure du Ruki jusqu'au poste, et les cours d'eau marécageux de la forêt. Ceux-ci sont de différentes longueurs, ils ont leur source dans la forêt et se composent en général d'un canal central bordé de marécages.

Quand on a affaire à un marais, le mieux c'est de le combler ; mais ici la dépense serait évidemment trop grande. Il ne faut pas penser à reconquérir le marais de l'embouchure du Ruki ; on pourrait cependant en enlever l'herbe sur une zone de 200 mètres, ou à peu près, dans le voisinage immédiat du poste. Cela permettrait au soleil de déssécher le sol, où on pourrait alors faire quelques plantations.

Le foyer de reproduction le plus dangereux, à Coquilhatville, se trouve peut-être dans les 30 derniers mètres d'une crique qui se jette dans le fleuve jusqu'en aval des baraquements. Le meilleur moyen de l'assainir sera le suivant : Rétrécir le chenal de façon à augmenter la force du courant et à empêcher l'embouchure de s'ensabler. Veiller à ce qu'il ne se forme pas d'irrégularités à la surface des berges et empêcher l'accumulation des herbes et des plantes aquatiques. Combler les marais, qui bordent le cours d'eau et couper l'herbe. Le but principal est d'ouvrir au menu fretin toutes les parties du marécage. On pourra appliquer les mêmes mesures à une petite crique et à un marais voisins de la source et à tous les endroits de reproduction du même type.

(*c*) TROUS DE LA BRIQUETERIE. Il y en a que l'on peut facilement combler. Il y en a d'autres que l'on exploite toujours. On les traitera par un culicide, ainsi que toutes les masses d'eau qu'il sera impossible de drainer à l'intérieur du poste.

Rapport sur Lusambo.

1. DESCRIPTION DU POSTE.

Lusambo est située sur une pièce triangulaire de terrain, bornée de deux côtés par le Sankuru et par un de ses petits affluents le Kabondo. Le niveau moyen du poste est à quelques mètres au-dessus du niveau du fleuve. Le sol, sablonneux, est de nature poreuse. Il est probable qu'une grande partie en a été amenée par les pluies, de la croupe de terrain qui borne le poste du troisième côté. Le niveau du marché s'est ainsi élevé de plus d'un mètre pendant ces deux dernières années. Deux immenses fissures dans cette croupe sablonneuse, au nord du poste, montrent par où les pluies ont entraîné ces tonnes de sable.

A une profondeur de 3 à 4 mètres et plus, règne une assise de grès. On n'a découvert d'argile qu'à un endroit dans le poste lui-même. Le sol est donc très poreux. Les pluies s'infiltrent rapidement, et, même à la saison des pluies, elles ne séjournent pas assez longtemps, dans la plus grande partie du poste, pour permettre aux moustiques de se reproduire. Du côté du fleuve cependant, il y a une couche très mince de terre à surface assez dure et peu perméable. Pendant la saison humide, il pourrait s'y former des flaques d'eau permanentes, surtout aux endroits où on a laissé pousser l'herbe en abondance.

Lusambo est donc favorisée par la nature du sol sur lequel elle est bâtie, et par l'escarpement des berges du Sankuru. Tout le long du fleuve, dans les limites du poste, il n'y a pas un endroit où les moustiques puissent se reproduire en temps ordinaire. A la saison humide, alors que le niveau du fleuve est très élevé, il y a trois endroits (indiqués sur la carte par la lettre A) où la berge a été emportée par les eaux de pluie, et où les moustiques pourraient se reproduire. On ne devrait sûrement pas négliger de boucher ces fissures.

A Lusambo le Sankuru a de 350 à 400 mètres de largeur. Sur la rive opposée, il y a de grands marais, où les moustiques ne peuvent manquer de foisonner. Bien qu'ils puissent, à l'occasion, se trouver transportés jusqu'à Lusambo, il n'y a pas lieu de croire, qu'il en puisse venir un assez grand nombre, pour compromettre les travaux d'assainissement qu'on se propose d'entreprendre dans ce poste.

La station elle-même est jolie. Quelques-unes des avenues sont bordées d'arbres ombreux et il y a sûrement de fort jolis bâtiments.

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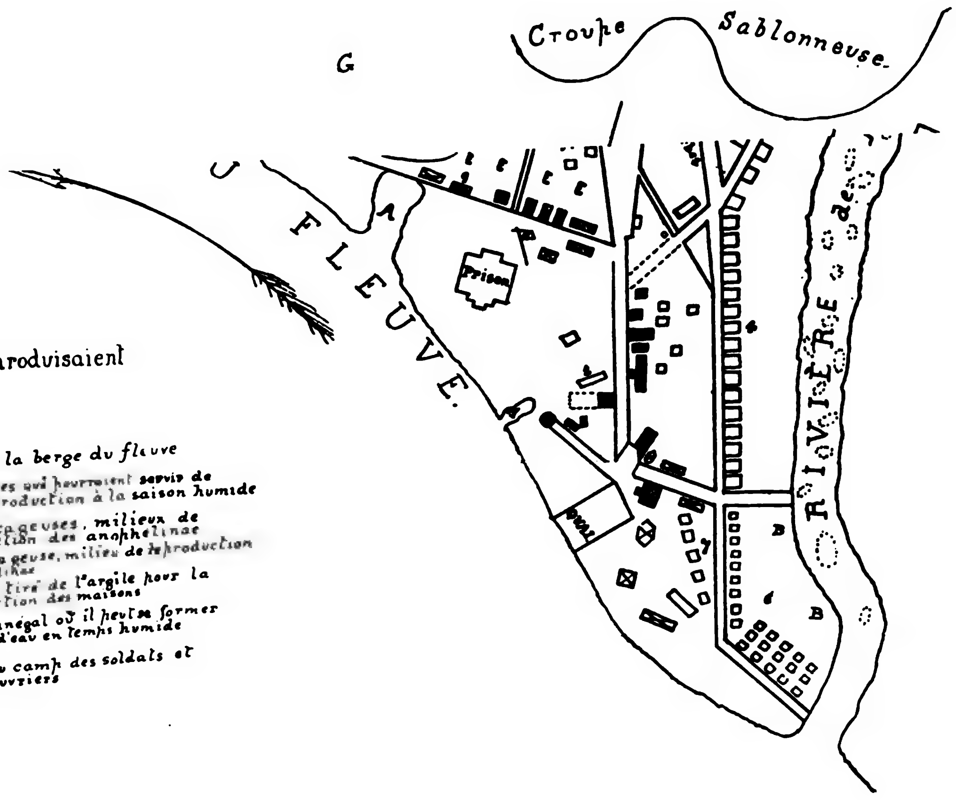

Plan de LUSAMBO
et ses environs.
montrant
les endroits où les moustiques se reproduisaient
(Jui[illegible]et 1905).

— Légende —

- ⊠ bâtiments inhabités
- ▬ maisons d'Européens
- □ maisons des Nègres
- 1 mess Européen
- 2, 3, 4, 5 } camp des soldats
- 6 camp des pagayeurs
- 7 maisons des "boys"
- 8 camp des ouvriers
- 9 maison de l'armurier

- A érosions dans la berge du fleuve
- B terrains vagues qui pourraient servir de milieu de reproduction à la saison humide
- C berges marécageuses, milieux de reproduction des anophélinae
- D. mare marécageuse, milieu de reproduction des anophélinae
- E trous où l'on a tiré de l'argile pour la construction des maisons
- F terrain bas et inégal où il peut se former des flaques d'eau en temps humide
- G site proposé du camp des soldats et des ouvriers

Echelle
1:1250 (environ)

Nous nous permettrons cependant de faire les critiques suivantes sur la disposition du poste et son entretien.

(1) Il y a beaucoup de maisons dans le quartier européen qui sont plus rapprochés les unes des autres qu'il ne serait désirable. Il devrait y avoir, autour de chaque maison d'habitation, un large espace où l'air pût circuler librement.

(2) Le quartier européen est presque complétement entouré de cases d'ouvriers ou de soldats indigènes. En outre plusieurs Européens ont des cases pour leurs "boys" à l'intérieur de leurs établissements. Le voisinage de ces résidences d'indigènes constitue un grave danger pour la santé des Européens.

(3) Une partie des plantations de café et du terrain inoccupé à l'intérieur de la station sont couverts d'herbes inextricables. Cette épaisse végétation empêchera certainement les flaques d'eau de s'évaporer à la saison des pluies et fournira ainsi aux moustiques des milieux favorables de reproduction. Ce serait un avantage pour le poste que d'avoir ces plantations, si on en prenait suffisamment soin.

Sur les bords du Kabondo et juste derrière la maison de l'armurier, du côté du nord-ouest, il y a d'autres endroits dont personne ne s'occupe et on y a laissé pousser une végétation beaucoup trop luxuriante.

2. MALARIA ENDÉMIQUE.

On a examiné* le sang de 49 enfants au-dessous de 10 ans pris dans les camps de pagayeurs et de soldats des bords du Kabondo et dans les deux camps de soldats situés au nord du poste (2, 3, 4, 6) 95·9% étaient atteints de malaria. Tous ces enfants avaient moins de dix ans, et, à l'exception de quatre, étaient tous nés et avaient toujours demeuré à Lusambo. L'Index endémique de Lusambo est donc élevé.

En 1888† il y avait de nombreux cas de malaria à Lusambo parmi les Européens et les indigènes et il s'en produit encore fréquemment. Le Dr. Polledro, du service médical du Congo, dit que les cas les plus fréquents se produisent aux mois d'octobre, de novembre et de décembre. Il est bon de rapprocher de ce fait que les fortes chutes de pluie commencent en septembre et que la température. s'élève alors légèrement.

* Au mois de juillet 1905.

† Rapport déjà cité sur le climat, sol et l'Hygiène du Congo.

3. PRÉSENCE DES *ANOPHELINÆ* À LUSAMBO.

Pendant notre séjour à Lusambo nous avons vu deux genres d'*Anophelinæ*, le *Myzomyia funesta* et le *Myzorhynchus paludis* dans les maisons des Européens et des indigènes. Nous avons trouvé beaucoup plus de moustiques de ces deux genres dans les maisons voisines du Kabondo et de son affluent avec le Congo que dans les autres parties de la station. Nous en avons par contre trouvé très peu dans le camp de soldats qui est le plus éloigné des milieux de reproduction (2 sur le plan). Nous avons pris des *Anophelinæ* dans un grand nombre de maisons d'Européens, particulièrement dans le voisinage du Quai.

Un grand nombre de ces moustiques ont été attrapés sous les tables ou dans les coins obscurs du mess. Ici, comme à Léopoldville, le mess, tel qu'il est à présent, est une source constante de danger pour ceux qui y fréquentent.

Vingt-six des *Myzomyia funesta* pris dans les baraquements de soldats ont été disséqués. Leur " estomac " et leurs glandes salivaires ont été examinés, et deux ont été trouvés atteints de malaria. Le nombre de moustiques examinés n'est pas, strictement parlant, assez grand pour nous permettre d'établir la proportion des sujets infectés. Dans ceux que nous avons examinés elle était de 7·5%.

Dix des *Myzorhynchus paludis* ont été disséqués et examinés ; on n'en a pas trouvé un seul de contaminé.

4. MILIEUX DE REPRODUCTION DES MOUSTIQUES A LUSAMBO.

Nous étudierons d'abord ceux qui existaient lors de notre visite à Lusambo en juin 1905. Nous parlerons ensuite des endroits, où ils pourraient, selon toute probabilité, se développer pendant la saison des pluies.

(1) Milieux de reproduction des *Anophelinæ* en juin 1905.

Ce sont les espaces indiqués en pointillé dans notre plan de Lusambo.

(1) Au plus fort de la saison des pluies le Kabondo serait un torrent de 8 à 12 mètres de largeur, encaissé entre des berges presque verticales. A cette époque de l'année il serait impossible aux moustiques de se reproduire dans le lit même de la rivière. A la saison sèche le Kabondo est presque à sec, et ce n'est en réalité qu'un

mince filet d'eau qui se jette dans le Sankuru. Le lit de la rivière est sablonneux ; l'eau change fréquemment de chenal et de nombreuses petites flaques d'eau, parsèment le sable à moitié desséché. C'est dans ces flaques d'eau que se reproduisent la plus grande partie des moustiques qui infestent Lusambo.

(2) A l'endroit indiqué sur le carte (C) les rives du Kabondo sont argileuses. Il y jaillit de l'eau à la surface, ce qui rend le sol marécageux. Il se forme ainsi de nombreuses petites flaques d'eau qui donnent naissance à un ruisseau qui se jette dans le Kabondo. Les milieux de reproduction ainsi créés sont couverts d'une herbe grossière, au milieu de laquelle il est assez difficile de retrouver les larves.

(3) A l'extrémité occidentale de la station il y a une mare d'eau marécageuse d'une assez grande étendue (D), où l'on a vu se reproduire de nombreux *Anophelinæ*.

(2) Milieux de reproduction pendant la saison des pluies.

(1) Les érosions dans les berges du Sankuru précédemment mentionnées et les inégalités qui se trouvent dans les parties basses des berges du Kabondo.

(2) Les terrains à surface inégale situés dans les bas-fonds dans la station elle-même (voir F sur le plan), en particulier les endroits déjà mentionnés comme couverts d'herbe (voir B sur le plan).

(3) Les fossés où l'on a pris de la terre pour la construction des maisons (voir E sur le plan).

(4) Les tranchées de draînage non pavées dans les limites du poste et dont beaucoup sont recouvertes d'herbe, offrant ainsi des milieux favorables à la reproduction des moustiques.

(5) Les tas d'ordures, les vieux pots, boîtes en fer-blanc, calebasses, etc.

(6) Par de très grandes pluies la nappe d'eau souterraine pourrait monter assez haut pour inonder les latrines "arabes," annexées à chaque maison d'Européen, et ces fosses d'aisances pourraient ainsi se transformer en foyers d'infection.

Les saisons à Lusambo ne sont pas nettement marquées. Il y a des chutes de pluie même en juin et en juillet, en pleine saison de sécheresse. La saison pluvieuse commence au mois de septembre. En octobre, novembre, décembre et janvier, ainsi qu'en mars et en

avril, il tombe de l'eau en quantités considérables, et cela presque tous les jours. Il faudra donc pendant ces mois empêcher soigneusement l'eau de s'accumuler.

5. RECOMMANDATIONS.

(1) Combler tous les trous qui se trouvent dans la station.

(2) Niveler les bas-fonds qui se trouvent derrière le camp des soldats (F sur le plan).

(3) Combler les crevasses et les basses terres qui se trouvent au bord du Sankuru et du Kabondo.

(4) Combler ou peupler de menu fretin la mare D du plan.

(5) Régler le cours du Kabondo. Enlever tous les obstacles au libre écoulement de l'eau, tels que troncs d'arbres, etc. Faire écouler ou combler avec du sable sec deux fois par semaine les flaques d'eau isolées qui se forment dans le lit du Kabondo.

(6) Reculer aussi loin du poste que possible les camps de soldats et de pagayeurs, ainsi que les cases de "boys" élevées dans le voisinage des maisons d'Européens. On pourrait peut-être mettre les soldats au nord de la station, du côté des deux endroits indiquées par G, tandis qu'on pourrait envoyer les pagayeurs de l'autre côté du Kabondo.

(7) Enlever l'herbe et les broussailles dans les plantations de café et dans les terrains inoccupés. On pourrait transformer ces terrains en terrains de culture, et faire de même pour les terres basses qui bordent le Sankuru, juste au-dessus de l'embouchure du Kabondo, ainsi que pour l'emplacement devenu vacant des baraquements de soldats et des pagayeurs. On pourrait y cultiver les récoltes de petite croissance, telles qu'arachides et patates douces qui pourraient servir à la consommation du personnel indigène du poste.

(8) Assurer l'aération du mess et y faire pénétrer plus de lumière ; faire procéder à un nettoyage complet, au moins une fois par semaine.

XI. Vapeurs Fluviaux.

Dans quelques postes des bords du Congo on nous a dit que les grands steamers fluviaux apportaient toujours des moustiques. Il peut aisément en être ainsi et cela pour deux raisons. Premièrement ils colportent les insectes d'un poste à l'autre ; deuxièmement les moustiques se reproduisent dans l'eau qui sejourne toujours à la cale.

En réalité les moustiques se reproduisent en grandes quantités dans certain steamers, et on trouve des *anophelinæ* dans presque toutes les cabines.

Le danger est evident. Si la fièvre jaune, par exemple, se déclarait dans un poste quelconque, les moustiques infectés seraient vite distribués le long du fleuve ou des rivières. La grande majorité des agents de l'Etat Indépendant font des voyages fluviaux plus ou moins longs, avant d'arriver au poste auquel ils sont attachés. On a souvent remarqué la fréquence des attaques de fièvre malarienne qui se produisaient sur eux dix ou quinze jours après leur debarquement. Il est très probable qu'ils se contaminent à bord. Il est donc désirable que les steamers cessent d'être des foyers d'inféction. On ne peut rémédier au mal qu'en empêchant les moustiques de se reproduire à bord, par l'emploi du pétrole ou de quelque autre culicide, comme la chaux, incapable d'endommager la cale ou la cargaison, et en mettant les cabines à l'abri des incursions des moustiques. On a fait des efforts en ce dernier sens dans quelques-uns des steamers que nous avons vus, mais sans résultat.

A présent un grand nombre de cabines manquent de lumière et ont une aération insuffisante. Nous proposerions, pour rémédier à cet état de choses, d'observer les points suivants dans la construction des cabines : les peindre à l'intérieur en blanc ou en gris très clair ; disposer l'ameublement de façon à laisser aussi peu de recoins obscurs que possible ; assurer autant que possible une aération meilleure que dans la majorité des cas ; quand on pourra le faire sans inconvénient, remplacer les planches au haut et au bas des cloisons par de la gaze métallique, sur une espace de 15cm. à partir du haut et de 20cm. à partir du bas. Avoir dans toutes les cabines une fenêtre munie, à l'extérieur, d'un rideau permanent de gaze métallique et, à l'intérieur, d'un châssis vitré pouvant s'ouvrir en dedans. Avoir une double porte pour toutes les cabines ; la porte intérieure se composerait d'un châssis tendu de gaze métallique et se refermerait automatiquement au moyen d'un ressort. La porte extérieure serait une porte de cabine ordinaire ; on aurait soin d'y pratiquer à la partie supérieure, pour laisser passer la lumière, une ouverture que l'on recouvrirait d'un filet métallique ; la partie inférieure serait à jour comme une persienne et également munie d'un filet métallique.

Les portes devraient s'emboîter parfaitement dans le chambranle,

de façon à ce que les moustiques ne puissent pénétrer par les interstices. On devrait recouvrir le seuil d'une plaque de laiton pour le protéger contre l'usure. Il faudrait disposer les deux portes de façon que leurs filets métalliques soient à plat contre les cloisons quand elles seraient ouvertes, et ne puissent par conséquent pas s'abîmer.

Il faudrait avoir soin de fixer solidement tous les filets métalliques de la cabine au moyen de châssis en bois à larges bords attachés par des vis. De cette façon on pourrait facilement remplacer les filets qui se déchireraient.

XII. Pollution par les Matières Fécales.

Un des besoins, qui se font le plus vivement sentir en particulier dans les postes les plus importants de l'Etat Indépendant du Congo, c'est la stricte application des règlements concernant l'établissement de latrines à l'usage des indigènes.*

On dit qu'on a essayé de les appliquer. A présent, en tout cas, on n'en tient aucun compte, et tout autour de Boma, de Matadi, de Léopoldville et de tous les autres postes, il n'est pas de recoin couvert d'herbes ou de broussailles, qui ne serve plus ou moins de latrines aux nègres. L'état de choses qui existe autour des "Produits de Mayumbe" (Rapport special, p. 28), est de règle et loin d'être exceptionnel.

Le danger que constitue cette dégoûtante habitude, est évident. On peut dire que 100% des indigènes, dont on a examiné les excréments, avaient des vers intestinaux. L'*Anchylostome duodenale* était le plus commun de ces parasites. L'*Ascaris lumbricoides* et le *Tricocephalus dispar* y étaient également fréquents. Or la dysenterie est une affection commune au Congo, également redoutée des blancs et des noirs ; et, une circonstance que nous indiquons, montrera combien cette pratique peut contribuer à la répandre. En 1903 on pompait l'eau nécessaire à la consommation de Boma, à l'endroit marqué "Prise d'eau" sur la carte. En dépit d'une ordonnance

* Voir l'arrêté du Gouverneur Général du 28 février 1892, publié dans le Recueil Usuel de la législation de l'Etat Indépendant du Congo, et, dans le même ouvrage la Circulaire du Gouverneur Général, du 1er août 1898. Le premier de ces actes édicte des peines sévères contre les personnes qui y contreviendraient.

prohibitive, on y trouva plusieurs excréments humains à quelques mètres de la rivière.

On nous a dit, qu'il était impossible d'obliger les indigènes du Congo à se servir de latrines.

On a pourtant vaincu cette répugnance des nègres dans d'autres colonies, à Bathurst dans la colonie anglaise de Gambie par exemple. Nous sommes convaincus que, si les latrines sont convenablement situées, bien construites et spacieuses, on pourra déterminer les nègres à s'en servir. Il faudra, bien entendu, que toutes les latrines soient tenues en bon ordre et dans un parfait état de propreté par le service public de santé. Avant d'essayer de rendre obligatoire l'usage des latrines publiques, il faut détruire l'herbe et les broussailles qui poussent dans le voisinage immédiat des postes. Il sera même probablement nécessaire, pendant quelque temps, de mettre des soldats de garde auprès des espaces vides ainsi créés, et de punir sévèrement ceux qui seront surpris y déposant des ordures.

Il faut défendre strictement aux particuliers la création de fosses d'aisances. Jusqu'à ce qu'on ait établi de vrais égouts et qu'on ait un bon service d'eaux, on ne devrait permettre que l'emploi des tinettes. Comme latrines publiques, on pourrait employer de grands récipients en métal. Pour les particuliers, nous recommandons l'usage des vases en faïence émaillée, tels qu'on les emploie au Sénégal. Importés par grandes quantités on pourra aisément les fournir aux indigènes au prix de quelques centimes seulement. Il faudra établir un jetée pour les vider et les nettoyer ; on fera bien de spécifier une heure détérminée et d'ajouter qu'ils devront être couverts lors du transport.

A Boma, il faudra probablement construire une jetée en aval de la Rivière des Crocodiles. On nous dit en effet que, lorsque le Congo est très haut, les ordures qu'on y jette du quai de la Marine, sont repoussées dans l'embouchure de cette rivière.

A Matadi le courant est très rapide. Il ne sera donc pas difficile d'y trouver un endroit convenable.

A Léopoldville, il est excessivement difficile de dire comment on pourrait se débarrasser de ces ordures. Par suite de la disposition du poste dans une baie formée par le fleuve, il ne faudrait pas qu'elles fussent jetées dans le Congo, avant le commencement des rapides, à plusieurs centaines de mètres du poste. Le camp occupé par les soldats et les ouvriers, est à plusieurs centaines de mètres de plus de

la rivière, et ce serait un travail considérable, que de porter ainsi, tous les jours, les déjections, au seul endroit où elles puissent être jetées dans le Congo, surtout avec une population de plusieurs centaines de nègres. A Léopoldville on tire l'eau d'une source (voir le plan) qui vient du pied de la paroi qui limite le plateau où s'élèvent les villages des travailleurs. Cela complique encore la question. Aussi préférons-nous ne pas faire de propositions et laisser le soin de résoudre le problème aux autorités compétentes qui peuvent l'étudier plus longuement sur place.

Dans les petits postes, qui ne sont pas situés au bord des grandes artères fluviales, on pourra enfouir les ordures dans des tranchées d'un mètre de profondeur, situées sur un emplacement sec, à quelque distance de l'établissement. Bien entendu, on ne devra jamais perdre de vue en prenant ces dispositifs l'endroit d'où l'on tire l'eau.

ADDENDUM

Pour donner une idée des dépenses nécessaires à une campagne contre les moustiques, nous ne pouvons mieux faire que d'emprunter quelques chiffres au rapport* qui vient de paraître sur les travaux d'assainissement à Ismaïlia (ville actuellement de 8,000 habitants). " Depuis le commencement de l'année 1903, les moustiques ordinaires " ont disparu d'Ismaïlia et tous le habitants ont pu supprimer leurs " moustiquaires.

" Depuis l'automne de 1903, il n'existe plus une seule larve " d'Anophèle dans la zone protégée, zone qui s'étend à l'Ouest à 1,000 " mètres des premières maisons du quartier arabe et à l'Est à 1,800 " mètres des premières maisons de la ville européenne.

" Depuis 1902, la fièvre paludéenne est entrée en décroissance " manifeste et depuis 1903 aucun cas nouveau de paludisme n'a été " constaté à Ismaïlia.

" Il est légitime d'admettre que le même résultat serait obtenu " partout ailleurs et qu'il ne sera jamais difficile d'obtenir le concours " des habitants d'une région dès qu'ils auront appris à connaître tous " les avantages résultant pour eux de la destruction des moustiques.

" Pour l'exécution des travaux les dépenses suivantes ont dû " être engagées :—

" 1. *Dépenses une fois faites.* Le comblement des mares et le " drainage des marais et cultures situés aux environs de la ville ont " nécessité une dépense de cinquante mille francs (50,000 fr.) environ, " y compris le coût des travaux effectués cette année pour l'abaissement " du plan d'eau du grand marais à l'Ouest d'Ismaïlia.

" 2. *Dépenses permanentes.* Le maintien en bon état des terrains " assainis par l'entretien des drains, le coupage des roseaux et les " chasses d'eau, ainsi que les mesures appliquées dans les habitations, " occasionnent une dépense annuelle de dix-huit mille trois cents " francs (18,300 fr.) environ se décomposant comme suit :

" Travaux d'entretien des terrains assainis aux environs de la ville : " 7,800 fr.

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* Suppression du paludisme à Ismaïlia, Paris. Imprimerie de la Société anonyme de Publications périodiques. 13 Quai Voltaire.

" Pétrolage des fosses, puits perdus et suppression des dépôts d'eau " de la ville : 10,500 fr. (dont : maind'œuvre, 5,200 fr. et matières " 5,300 fr.)."

Comme examples de règlements sanitaires récents citons la législation suivante :—

(1) A Nouvelle Orleans, " A water cistern screening ordinance ; " No. 3,196 New Council Series, August 2, 1905 ; An ordinance pre- " scribing the manner in which water liable to breed mosquitoes shal " be stored within the limits of the city of New Orleans ; "

(2) Dans le Honduras Britannique, " Ordinance No. 1, 1906 ; An " ordinance to secure the destruction of mosquitoes in order to prevent " the spread of disease."

(3) A Sierra Leone, " Public Health Ordinance, No. 15 of 1905 ; " An ordinance to consolidate and amend the law relating to Public " Health in Sierra Leone."

Ce dernier règlement est de loin le plus complet.

ANIMAL REACTIONS OF
THE SPIROCHÆTA OF
AFRICAN TICK FEVER

OBSERVATIONS ON THE ANIMAL REACTIONS OF THE SPIROCHÆTA OF THE AFRICAN TICK FEVER*

BY

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(From the Runcorn Research Laboratories of the Liverpool School of Tropical Medicine.)

A PRELIMINARY NOTE.

The strain of spirochætæ used for the following experiments was that discovered by Dr. J. E. Dutton and Dr. J. L. Todd in cases of human tick fever occurring in the Eastern part of the Congo Free State and brought to England by Dr. Todd in the infected monkeys and ticks. Their observations are published in one of the memoirs† of the Liverpool School of Tropical Medicine. From one of the monkeys infected by ticks which died showing numerous spirochætæ in the blood sub-inoculations were made intraperitoneally into three rats, two receiving five cubic centimetres and one seven cubic centimetres (Experiment 985). The smallest of the rats, about one and a half months old, showed spirochætæ in the blood at the time of the first examination some 14 hours after inoculation. The number of spirochætæ increased rapidly until, at the time of the rat's death, which occurred suddenly five hours later, the corpuscles were entirely obscured by the innumerable parasites present in the blood. In the case of the other two rats (both full grown)

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* Reprinted from *The Lancet*, March 10, 1906.

† Dutton and Todd: The Nature of Human Tick Fever in the Eastern Part of the Congo Free State, Memoir XVII, Liverpool School of Tropical Medicine, Liverpool, 1905.

parasites were present in the blood in small numbers 12 hours after inoculation (one to one to three fields: Zeiss oil immersion $\frac{1}{12}$, ocular 4) and were found continuously in large numbers until the rats died, one (985 B) after four days and the other (985 A) after seven days. Sub-inoculations from 985 B were made into two rats, (Experiment 990), A getting two cubic centimetres and B one cubic centimetre of blood intraperitoneally. The spirochætæ were found at the time of the first examination (16 hours after inoculation) in large numbers and increased for four days when both rats died, showing innumerable parasites.

Further sub-inoculations made from this strain have shown that the incubation period varies between two and six hours in the rat if blood containing numerous spirochætæ be used for the inoculations. The incubation period, however, may be prolonged, as is shown in one case, to nine days or even as long as 21 days in another case. The blood used for this inoculation was derived directly from a monkey infected by means of the bites of infected ticks and which had had a short attack, the spirochætæ being at first present only in small numbers and afterwards absent for two weeks and finally very scarce (one to a preparation) just before death.

The duration of the disease in rats varied between one and 45 days and was increased by the passage of the spirochætæ through several rats. A noticeable feature in those rats in which the disease ran a longer course was the gradual increase in the number of parasites for a few days until in many cases they were uncountable, followed by a corresponding decrease in number to complete disappearance. After a short period of absence the spirochætæ again reappeared and the cycle was repeated three or four times before the animal died, but during the "relapses" the number of parasites never rose so high as in the first attack.

From the pathologico-anatomical point of view the most striking feature was a more or less pronounced enlargement of the spleen (sometimes thrice the normal size). Very frequently this organ contained hæmorrhagic infarcts of varying size, in some cases involving half the spleen. Often the process had proceeded further and small anæmic infarcts were found. The Malpighian bodies were enlarged and greyish in colour. The trabecular system was not pronounced. The liver usually was enlarged and showed hæmor-

rhages under the capsule and in its substance. Small necrotic areas were found scattered through the liver substance. The bone marrow was very soft and of a pale greyish colour. Petechiæ in the serous membranes were frequent.

Six mice were inoculated intraperitoneally with from 0·2 to 0·5 cubic centimetre of citrated blood containing many spirachætæ. All showed the parasites in the peripheral circulation the following day. Four died during the course of this day showing from one to six spirochætæ per field; two died after 48 hours with numerous parasites in their blood. At the post-mortem examination the spleen was found to be much enlarged in every case.

Six adult rabbits were inoculated intraperitoneally with large amounts of heavily infected citrated blood (from 10 to 20 cubic centimetres) from monkeys and rats. The animals usually showed parasites in the peripheral blood within from two to three hours afterwards; the number of these increased, as a rule, for the first day and a half (in one case the spirochætæ were so numerous that they could not be counted), then decreased until, after three days, the blood examinations were negative. The temperature of the rabbits rose from 100°-101° to 104°-105° F. within about six hours and fluctuated between 105° and 106·6° until the death of the animals, which occurred in from three to ten days. Marked symptoms of malaise were noticeable shortly after the inoculation and continued until death. Sub-inoculations into rats were positive only in the case of one rabbit which died the third day after inoculation. The post-mortem findings were similar to those found in the rats but usually more marked in severity. The spleen was enlarged and showed hæmorrhagic and anæmic infarcts, the liver showed necrosis, and the bone marrow was very soft, and scattered through the reddish marrow were numerous greyish areas.

Four guinea-pigs were inoculated, also intraperitoneally. Two, inoculated with 15 cubic centimetres of blood showing from 20 to 30 spirochætæ per field, showed parasites in small numbers the following day (1 to 40 fields) and died on the third day showing in the heart blood from one to ten spirochætæ in each microscopical field. The temperature showed a marked rise, reaching 104°. Two, inoculated with five cubic centimetres of infected blood, showed parasites in the peripheral circulation two hours later. The spirochætæ increased in

number until the next evening, when from one to two per field were seen and then decreased. After the third day the blood examinations were negative. The temperature fell to normal and both are still alive (one 36 days and the other 27 days after inoculation). In the guinea-pigs which died slight enlargement of the spleen was the only visible finding.

One dog (nine months old, mongrel), Experiment 1018, was inoculated intraperitoneally with 15 cubic centimetres of citrated blood showing numerous spirochætæ. Two hours later parasites were found in the peripheral circulation; they increased in number till the next evening when there were from five to eight in one field of the stained specimen and then decreased. On the fourth day no parasites were found and the blood has since remained free from spirochætæ. Sub-inoculations into rats proved negative. Within six hours of the inoculation the temperature rose from 100° to 103·2° and after the third day fell to normal with no subsequent rise.

One pony, Experiment 1019, was inoculated intraperitoneally on January 16th with 17 cubic centimetres of pure heart's blood from a rat showing from five to 20 spirochætæ per field. Seven hours later four spirochætæ were seen in one-half of the film specimen of blood. At the same time the number of leucocytes was increased. The parasites increased in number during the next day until, in the evening, from one spirochæta in two fields to from one to 25 parasites per field were seen. They were still present on the third day but on the fourth day had disappeared and have remained absent since. Corresponding to the appearance of the spirochætæ the temperature rose from 98·6° to 103°, maintained that level for three days, and fell on the fifth day to 99·8°. No rise of temperature has been observed since.

One monkey, an adult Cercopithecus, was inoculated subcutaneously with one cubic centimetre of blood (from 60 to 80 spirochætæ per field). Parasites in small numbers were seen in the blood 24 hours later. A corresponding rise of temperature was noticed. The spirochætæ increased in number and disappeared after three days. At certain intervals the parasites were seen in the peripheral blood, being present for a few days and then disappearing again.

Monkeys showed blood infection after an incubation period of five days after the bites of infected ticks. In monkeys which died from

the infection the spleen and liver were found to be the most markedly changed. The spleen was considerably enlarged and contained anæmic infarcts of varying size and extent corresponding to the duration of the disease. In some cases the spleen substance contained very numerous small necrotic areas about a millimetre in diameter. The liver contained hæmorrhagic areas and small necroses. The bone marrow was soft and greyish-red in colour.

From the above experiments it is apparent that we have been able to infect with spirochæta of African tick fever in addition to monkeys, a horse, a dog, rabbits, guinea-pigs, rats, and mice. The rabbits, rats, mice, and some of the guinea-pigs have succumbed to the infection. Previous observers have not been able so far as is known up to the present, to infect any animal other than monkeys with the *Spirochæta obermeieri*. These experiments lead to the conclusion that the spirochæta of the African tick fever differs from the *Spirochæta obermeieri*. While the animal reactions are different from those of the *Spirochæta obermeieri*, the pathological anatomical lesions are the same as those described in human beings who have succumbed to the infection by *Spirochæta obermeieri*.

THE SPECIFIC NATURE OF THE SPIROCHÆTA OF AFRICAN TICK FEVER

ON THE SPECIFIC NATURE OF THE SPIROCHÆTA OF THE AFRICAN TICK FEVER*

BY

ANTON BREINL, M.D.

ASSISTANT LECTURER IN TROPICAL MEDICINE

(From the Runcorn Research Laboratories of the Liverpool School of Tropical Medicine.)

Further studies of the spirochætæ of the African tick fever, brought home by Dr. J. L. Todd from the Congo Free State, have now been conducted. Through the kindness of Dr. Norris† and Dr. Terry, to whom I express my great indebtedness, we were able to compare the African strain with one derived from a case of relapsing fever in New York. This was identified by Novy‡ as *Spirochætæ obermeieri* and in this note will be called " O " strain.

A short preliminary report§ on the animal reactions of the spirochæta of the African tick fever was published from these research laboratories. Further inoculations were made in monkeys. Some species—*e.g.*, *Macacus rhesus*, *Cercopithecus*—survived the infection and have apparently recovered, since tame mice and rats, in our experience the animals the most susceptible to the African spirochæta, inoculated with large amounts of the monkey's blood, did not become infected.

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* Reprinted from *The Lancet*, June 16th, 1906.

† Norris: A case of Spirochætal Infection in Man, Proceedings of the New York Pathological Society, No. 4-8, p. 93. Preliminary Communication upon a Spirochætal Infection of White Rats, &c., loc. cit., p. 162.

‡ Novy and Knapp: *Spirochæta obermeieri*, Journal of the American Medical Association, Jan. 13th, 1906.

§ Breinl and Kinghorn: Observations on the Animal Reactions of the Spirochæta of the African Tick Fever, *The Lancet*, March 10th, 1906, p. 668.

A large *Cercopithecus* (Experiment 1015) was inoculated on January 15th. It passed through the ordinary course of the infection, had two relapses, and after February 15th no spirochætæ were seen in spite of twice-daily examinations by the thick-film method. It was re-inoculated on April 2nd, and on the 5th a rise of temperature was noted from 102° to 105° F., but in spite of most careful examination no spirochætæ could be seen. A white rat sub-inoculated on the 5th did not become infected. The second re-inoculation of the monkey on May 5th was was not followed by even a rise of temperature. A second "Sooty" monkey of the same species followed a similar course.

A *Macacus rhesus* was infected through tick bites. It had only one relapse, and the sub-inoculation, four weeks afterwards, was negative. On the second evening after re-inoculation (eight cubic centimetres of heavily infected heart blood of a rat) two spirochætæ were seen in a preparation, but on subsequent occasions none could be found.

Similar observations were made on a large *Cercopithecus callitrichus*. The re-inoculation was followed by a marked rise in temperature, and although no spirochætæ could be seen in preparations of the peripheral blood, a rat inoculated with five cubic centimetres became infected after a prolonged incubation period of seven days. Those rats which had recovered from the disease were re-inoculated with large amounts of heavily infected blood at various intervals. Of seven only one showed parasites in the blood after re-inoculation. Spirochætæ were seen eight hours afterwards; these disappeared within twelve hours and were never seen again. Monkeys inoculated with the strain of spirochætæ obtained from the New York case passed through a similar attack and had the usual relapses—one after a negative interval of nineteen days. Re-inoculations with the same strain resulted in much the same manner as noted in similar infections with the African spirochætæ. In one case the sub-inoculation of a white rat on the first day after the re-inoculation of the monkey was followed by the infection of the rat, although no parasites could be seen in preparations from the monkey's peripheral blood. Further sub-inoculations made some days later from this monkey were not followed by infection.

The course of the disease in rats inoculated with "O" strain was

quite different. The parasites were never so numerous and were never present for so long a time as in the case of the African strain (maximum—three days for the New York strain, seventeen days for the African). Relapses were also observed, but never more than two. With the African strain three relapses were quite common. The re-inoculation of four rats was followed by infection in only one case, the parasites being present in the peripheral blood for one and a half days.

From the above experiments the conclusion must be drawn that there exists, to a certain degree, active immunity against re-infection in the case of "O" and African strains respectively, as only a small percentage of the rats and monkeys became re-infected, and then showed only a slight infection. The monkey, mentioned above, which was inoculated twice with the "O" strain, was inoculated after a certain time with the African strain. Spirochætæ were found in the peripheral blood on the next day, and remained present for three days in the same way as was observed in monkeys inoculated with the African strain originally; in fact, the course of infection was similar to that of a *first* infection with spirochætæ in the monkey. In one rat (Experiment 1078) inoculated with the New York spirochætæ, which had been kept in defibrinated blood for twelve days, the blood examination did not reveal the presence of the parasites, most probably on account of insufficient observations. In spite of very careful examination no spirochætæ were seen in this rat after two re-inoculations, one four weeks, the other seven weeks after the original inoculation. The rat, however, became infected after nine hours when inoculated with the *African strain*, eight days after the last re-inoculation, and has two relapses since. Another rat (Experiment 1122) inoculated with "O" strain showed the parasites for three days and had one relapse. Five weeks later it was re-inoculated with the same strain, but the parasites were not seen. When inoculated seven days later with the African strain the rat passed through a course of infection similar to that of the previously untreated control rat. Two rats which were inoculated with the African strain and which had not shown parasites after re-inoculation with the same strain (Experiment 1081) four and a half weeks after the original inoculation, with six cubic centimetres of heavily infected blood, and which, four and a half weeks after this again, were

inoculated with the "O" strain, became infected in the same mannei as the controls.

From the above one must draw the conclusion that the spirochæta of the African tick fever is of a species differing from that of the New York spirochæta, in that each confers a relatively active immunity against itself but not against the other. I would therefore suggest for the spirochæta of the African tick fever the name of *Spirochæta duttoni*.

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OF

THE LIVERPOOL SCHOOL OF TROPICAL MEDICINE

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PREFACE

THE communications incorporated in this volume represent a part of the results of work done at the Runcorn Research Laboratories of the Liverpool School of Tropical Medicine, since September, 1905; further publications will soon follow. All the work has been done on material brought to England by the Expedition of this School to the Congo Free State.

The thanks of the Runcorn Laboratories are due to Professor Ronald Ross, to Professor Sherrington, to Dr. J. W. W. Stephens, and to the Dean of the Liverpool School of Tropical Medicine, Professor Boyce, for the encouragement they have given. Much valuable advice and practical assistance received from Professor H. E. Annett is gratefully acknowledged. The generous aid afforded by the Chairman of the Liverpool School of Tropical Medicine, Sir Alfred Jones, has made it possible to carry out extensive animal experiments.

Those who have studied for different periods in the Runcorn Laboratories, or who have done work in connection with them during the past year, are:—Anton Breinl, M.U.Dr. Prag, Captain R. Markham Carter, I.M.S., J. W. B. Hanington, M.D., C.M., Allan Kinghorn, M.B., R. Howard Mole, M.D., Robert Newstead, A.L.S., F.E.S., Egerton L. Pope, B.A., M.D., P. A. H. Radcliffe, M.B., E. N. Tobey, A.B., A.M., M.D., Lewis Williams, M.D., D.P.H., R. Stenhouse Williams, M.B., D.P.H. It is pleasant to acknowledge the enthusiasm which has characterised their work.

From December, 1905, to April, 1906, the full management of the laboratories fell upon Dr. Breinl.

JOHN L. TODD,
DIRECTOR

THE RUNCORN RESEARCH LABORATORIES OF THE
LIVERPOOL SCHOOL OF TROPICAL MEDICINE
September, 1906

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PLATE I.

The Runcorn Research Laboratories of the Liverpool School of Tropical Medicine.

The Runcorn Research Laboratories

OF THE

Liverpool School of Tropical Medicine

The experimental work on trypanosomiasis which has been done in England by the Liverpool School of Tropical Medicine was commenced in 1903 with the material brought back from the Gambia by the late Dr. J. Everett Dutton. At first the researches were carried on in the Johnston Laboratories in Liverpool, but, as the work expanded and succeeding expeditions brought home further material, it became necessary to find more spacious quarters than could be had in the city. In September, 1904, accommodation was therefore taken at Crofton Lodge, Runcorn, sixteen miles from Liverpool, and laboratories were fitted up; ample stabling and pasture for all sorts of animals was obtained on a small adjoining farm. Work was commenced at once under these new and more favourable conditions.

Until the return, in September, 1905, of the Expedition of the Liverpool School of Tropical Medicine to the Congo, the chief energies of the newly-founded laboratories were devoted to the study of the various trypanosomiases.* Since September, 1905, their work has mainly been concerned with the spirochaetes causing a relapsing fever in man.

An important function of the laboratories is to supply living parasites for the practical instruction of students taking the course in Tropical Medicine given by the Liverpool School at the Johnston Laboratories. For teaching purposes, as well as to provide material for research work, the trypanosomes of Dourine, Mal de Caderas, Nagana, Gambian horse disease and "Sleeping Sickness" are constantly kept going in animals. The spirochaetes of "Relapsing Fever," and of mice (*Spirochaeta laverani*), of "African Tick-fever," and of fowls, are kept on hand for the same purposes. The ticks,

* Memoir XVI of the Liverpool School of Tropical Medicine.

Onithodoros moubata and *Argas miniatus*, which transmit the two last named diseases are bred in the laboratories. Ticks, *Ixodes reduvius* and *Rhipicephalus annulatus*, which transmit the piroplasms causing " red water " in cattle are also at hand.

The presence of these parasites alone insures a rich supply of material for research work. In addition, a large part of the collections of parasites and pathological material made by the Expeditions to the Gambia and to the Congo, has been taken to Runcorn to be studied.

The equipment of the laboratories, while not elaborate, is very complete, and enables those working at Runcorn to take full advantage of the splendid material at their disposal.

The accompanying photographs give a good idea of some of the work rooms and of the monkey houses. The rooms for small, infected and stock animals (rabbits, rats, mice and guinea-pigs) are not shown. One very great advantage, resulting from the situation of the laboratories in the country, is the ease with which the larger animals (horses, donkeys, goats, sheep and dogs) can be maintained. The housing of large animals is no longer a factor important enough to prevent the performance of a desirable experiment.

It is part of the purpose of the Runcorn Laboratories to extend every facility to those who desire to engage in research work.

PLATE II.

VIEWS IN THE WORK ROOMS.

PLATE III.

VIEWS IN THE WORK ROOMS.

PLATE IV.

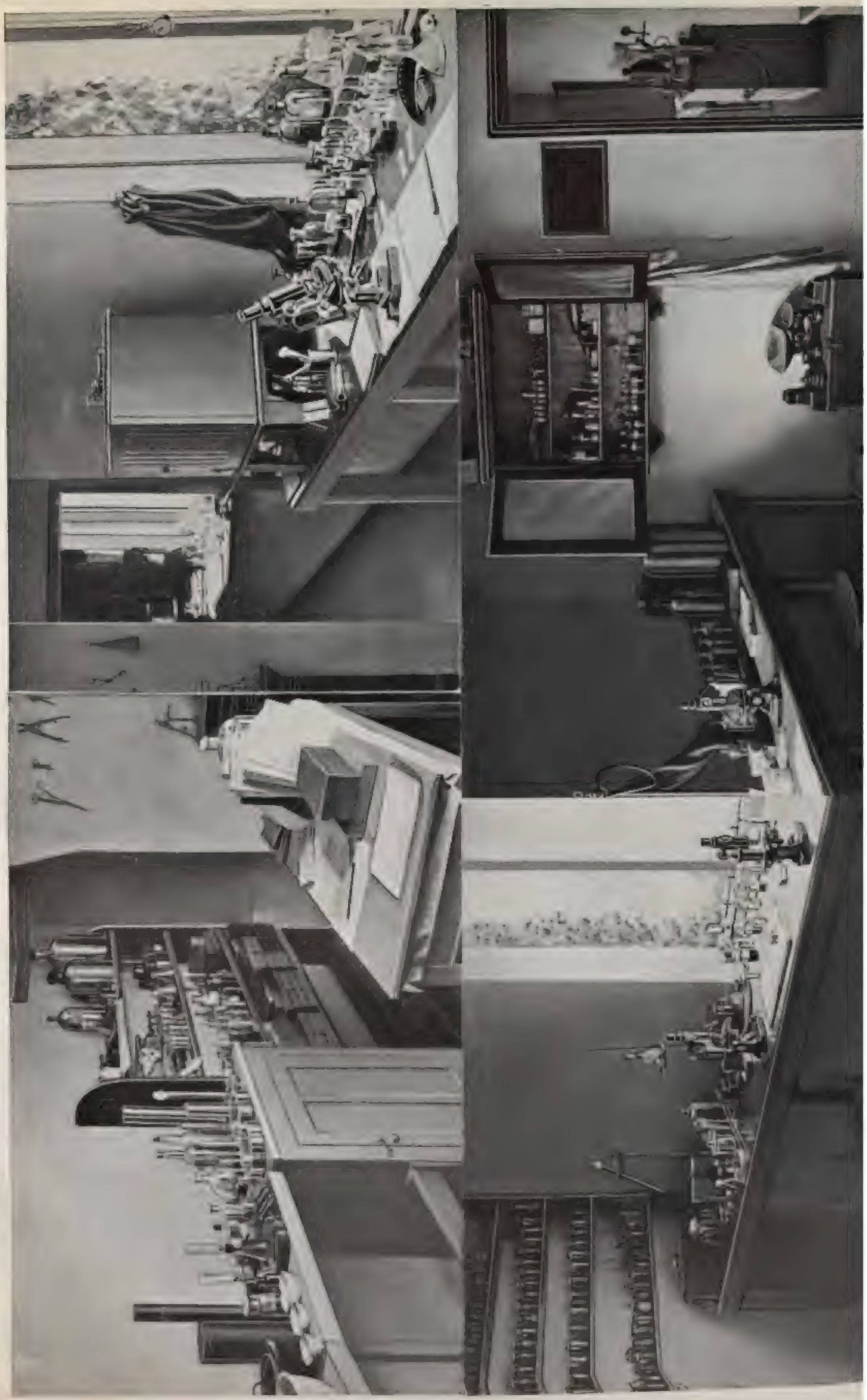

PLATE V.

SOME OF THE ANIMALS.

AN EXPERIMENTAL STUDY OF THE PARASITE OF THE AFRICAN TICK FEVER

(Spirochaeta duttoni)

CONTENTS

CONTENTS

AN EXPERIMENTAL STUDY OF THE PARASITE OF THE AFRICAN TICK FEVER

(*SPIROCHAETA DUTTONI*)

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From the Runcorn Research Laboratories of the Liverpool School of Tropical Medicine

I. Introduction

The work embodied in the following pages was done with the spirochaete found to be the cause of the African tick fever by Dutton and Todd[8] in the Congo Free State. The parasites were brought home in infected ticks, and the strain was recovered from monkeys which had been infected through their bites. In their report,[8] Dutton and Todd state that the parasite is identical with *Spirochaeta obermeieri*, but further study of the animal reactions, and the results obtained by inoculating animals immune to tick-fever or European relapsing fever with the causative agent of the other disease, have shown that the spirochaete of tick fever differs from that of ordinary relapsing fever. We have, therefore, called the parasite of African tick-fever* *Spirochaeta duttoni* in honour of the late Dr. Dutton.[6]

We have been enabled to make a direct study of the disease in four cases contracted in these laboratories during the progress of the work by one of us and three of the laboratory assistants.

The morphology of the parasite will not be discussed fully in this report, but will be reserved for a future publication.

* After a study of two slides sent from these laboratories, and of the few experiments given by Dutton and Todd, Novy and Knapp, in a paper[24] published six weeks earlier than ours, considered that they had sufficient evidence to call this spirochaete a new parasite, which they accordingly named *Spirillum duttoni*.

II. Technique

The routine method of examining the blood for spirochaetes the ordinary thick-film one. Two or three drops of blood were pl on a perfectly clean slide and then spread out over a sur 2 × 3 cm. After drying in the air, the films were fixed in the flam the same way as a bacteriological specimen and the haemoglobin removed by washing the films in distilled water. After being treated, they became quite colourless and were then stained Romanowsky's stain for half an hour. The stain was made accordance with the directions given by Stephens and Christopher:

A.	Medicinal methylene blue	1 part.
	Sodium carbonate	0·5 „
	Distilled water	100 „
B.	Eosin	1 : 1000 „

Before using dilute each solution with 19 parts of distilled w and then mix in equal parts for staining. This method gave us be results than any other modification of Romanowsky.

In specimens prepared by this method the spirochaetes are defined and of a deep purple colour. The leucocytes are well-stai while the red cells appear as mere shadows. The examinatio much facilitated by reason of this.

For more detailed study, very thin films were made on slides he to 37° C., in order to dry the blood film more rapidly; these were f in absolute alcohol and stained with the above modificatior Romanowsky and by Giemsa's and Laveran's method. In our h Marino's method did not yield satisfactory results.

When the presence of precipitates interfered with examinatio was found advisable to place the preparations in oil of cloves f short time, and then in xylol after the excess of oil had been blo off.

Carbol-fuchsin stains the spirochaetes very readily and inten but is not as valuable a stain as Romanowsky. Heidenhain's i haematoxylin was also used, but without any advantage, as it st the spirochaetes uniformly black.

In order to study the structure of the parasite the wet film me was used. Perfectly clean slides were covered with an exceedi

DISEASE.

TICK FEVER

Notes of Case

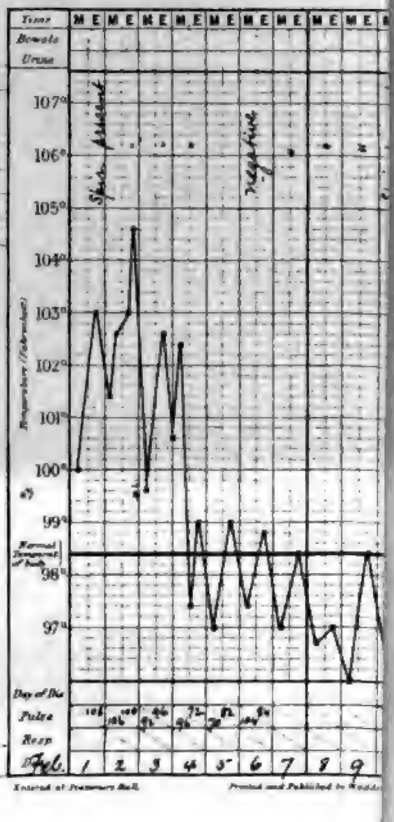
Name A.B.

Age

Diet

Case Book No

Chart 1.



Date of admission

Result

thin layer of Mayer's albumen. A drop of blood was spread out as quickly as possible over the layer of albumen, and while still wet the slide was dropped into Flemming's fixing solution and left for ten minutes. In this the albumen was quickly coagulated and firmly fixed the blood to the slide. From the fixing solution the slide was passed through the different alcohols and stained.

Grawitz's method for cutting sections of the blood was also employed, but we were not successful in seeing spirochaetes in the sections.

The routine examination was made with a Zeiss 1/12 oil immersion and No. 4 ocular. The number of spirochaetes given throughout this publication refers to the number that were seen in the field thus obtained.

III. Description of Cases of African Tick Fever in Whites

CASE I (Chart I)—A.B. European, age 26. Felt sick February 1st, 1906. No prodomal symptoms were noticed other than profuse sweating the previous day with no apparent reason. On arising in the morning the patient felt tired, but was able to work as usual until the afternoon, when he was suddenly seized with aching in the lower limbs, slight headache and a marked degree of fatigue. At 2 o'clock, when first taken, the temperature was 100° F., and in the course of the next eight hours rose to 103° F. Preparations of the peripheral blood were made early in the afternoon, and the characteristic parasites were found. The symptoms became steadily worse as the temperature rose, and the most predominant was an intense pain in the region of the spleen. The slightest pressure there caused paroxysmal pain. A slight diarrhœa had been noticed during the day. In the evening the patient vomited once, and was finally forced to go to bed on account of the diffuse headache and very severe pain in the bones and spleen. An intense feeling of chilliness persisted in spite of all measures to relieve it. The physical examination, in addition to the general symptoms of fever, revealed slight enlargement of the spleen, the free border of which could be palpated one finger's breadth below the costal margin.

During the night the symptoms became more severe, and the patient was very restless and sleepless. On the morning of the 2nd

the temperature fell slightly, but there was no amelioration in the severity of the symptoms. Great thirst was noted and also slight coughing, which was suppressed on account of pain caused by it in the splenic region. In the afternoon the temperature again rose, and at 10 o'clock had reached 104·6° F., the highest reading observed during the disease. With the increase in temperature the pain became worse, and slight delirium set in. The symptoms continued without much amelioration until the night of the 4th when the crisis occurred, accompanied by heavy sweats. The temperature fell below normal and with this the characteristic symptoms disappeared completely, leaving the patient very weak and tired. A noticeable feature was the pseudocrisis on the third day of the disease, which was not followed by a corresponding improvement in the condition of the patient.

The parasites were found in preparations of the blood with the first rise of temperature, 1 to 10-25 fields, and the number increased slightly until, on the second day, from 2-3 per field were counted. At the time of the crisis one parasite to 150 fields was seen, and none were found in the preparations made on the following day.

The only changes found in the blood were a slight decrease in the number of the erthyrocytes, with a fall in the percentage of haemoglobin and a marked leucocytosis just before the crisis. In stained specimens, polychromatophilic degeneration of the red cells and a very decided increase in the number of platelets were noticeable.

After the crisis the patient regained his appetite, and the feeling of sickness slowly passed away.

On February 10th a relapse occurred. With the rise in temperature the original symptoms reappeared; the parasites, which had not been seen in the peripheral circulation during the interval, were again present and did not disappear until twenty-four hours afterwards. As in the original attack, the headache and pain in the long bones and spleen increased steadily in severity until the temperature reached its maximum. A pseudocrisis was observed on the 13th, but the symptoms persisted until the true crisis on the following day. Marked sweating accompanied this fall of temperature.

At intervals of eight days, four more relapses followed. Each time the symptoms came on very suddenly, increased in intensity

with the rise of temperature and disappeared with the crisis. Each succeeding relapse was less severe than the previous one.

Other remarkable features of the disease were the very great thirst experienced during the whole of the attack, and the loathing for food during the febrile period. In the intervals of apyrexia the patient recovered to a great extent, and was able to pursue his occupation.

After the last relapse on the 22nd March, the patient quickly recovered his usual health, and the only abnormality was a subnormal temperature in the morning, at times as low as 95° F. On the 22nd of April, another attack occurred in which the symptoms were of peculiar intensity. With the height of the fever the patient was very restless and delirious. After a pseudocrisis on the previous day, there was a critical fall of the temperature on April 24th. No further relapses have occurred since.

Treatment

As quinine and other forms of treatment of relapsing fever are very unsatisfactory, it was thought advisable to try the effect of Atoxyl, which has such a marked effect in the treatment of experimental trypanosomiasis.[37] It was given hypodermically for a fortnight in daily doses of 0·6 ccm. of a 20 % solution, increasing to 1 ccm. No effect either on the disease or on the parasites was observed.

The mode of infection in this case seems well defined. Seven days previous to the onset of the symptoms the patient was performing an autopsy on a heavily-infected monkey, and in the course of this abraded the skin of his hand.

Subinoculations into eleven rats and one monkey were made.

On February 2nd, two rats were inoculated with 0·6 and 0·8 ccm. of citrated blood and showed parasites in preparations of the peripheral blood on the following day. On the third day after inoculation both died from pneumonia.

One rat was inoculated on the 6th of February with 0·2 ccm. of citrated blood, was infected on the 11th (5 spirochaetes in film) and shewed the parasites for fourteen consecutive days, during most of the time numerously.

On the 11th, two rats were inoculated with 0·8 and 1 ccm. of citrated blood respectively. Parasites were found in blood preparations on the fifth day, and were continuously present for 10 and 12 days.

The monkey was inoculated on the 22nd of February and became infected on the evening of the 23rd. It passed through an attack of five days duration, with three relapses, and showed parasites in preparations of the blood for the last time on March 23rd. Two rats were inoculated at the same time with 2 ccm. of citrated blood, and both had an attack followed by two relapses.

It is of interest to point out here, that one rat, Experiment 1,042, inoculate on the 6th, when the patient's blood was negative to microscopical examination became infected on the 11th, the day on which the patient had his first relapse.

Another rat, Experiment 1,043, inoculated on the 8th, showed parasites fo the first time on the 10th, when the spirochaetes reappeared in the patient's blood

Experiment 1,049.—Rat, inoculated on the 19th of February, and showe parasites in blood preparations on the afternoon of the 22nd, agreeing perfectl with the onset of a relapse in the patient.

Experiment 1,064.—Rat, inoculated with 3 ccm. of citrated blood on Marc 22nd and never became infected. Reinoculated on the 5th of April from a infected rabbit and showed spirochaetes in preparations of the peripheral bloo after an incubation period of three days.

Experiment 1,110.—Rat, inoculated on the 22nd of April and showed spiro chaetes in preparations of the peripheral blood made on the following day. I passed through an attack and two relapses.

A consideration of the experiments outlined above show that the blood of patients suffering from relapsing fever i infective for susceptible animals during the periods of apyrexia Rats so inoculated showed the parasites for the first time in bloo preparations at a period closely agreeing to the onset o the succeeding relapse in the patient; in one case even at the same hour.

In view of the remarkable fact that the rat which was inoculate from the patient on March 22nd, when a marked rise in temperatur occurred, did not become infected, whereas the one inoculated a month later did so, we are inclined to consider the "relapse" o April 22nd as a *re-infection.* The shortness and severity of thi attack are also in accord with the facts published by other authors *e.g.*, Litten,[14] about re-infection.

CASE II (Chart II)—J. Fg. European, age 18. Previously healthy. On the 21st of June he came to work as usual, but complained of headache, diarrhœa and aching in his legs and spleen. Later in the morning he vomited a greenish, slimy fluid, and was sent home to bed, as a temperature of 101° F. was found. Preparations of the blood were examined in the afternoon, and showed spirochaetes in scanty numbers (1 to ½ film). He passed a sleepless night on Thursday, but felt somewhat better on Friday, although he had no appetite and was very thirsty. On Saturday he felt so much better that he thought he would be able to work again, but on Sunday was seized with an exacerbation of all the previous symptoms accompanied by a rise in temperature to 104·8° F. The examination of blood films

DISEASE.

Tick Fever

Notes of Case.

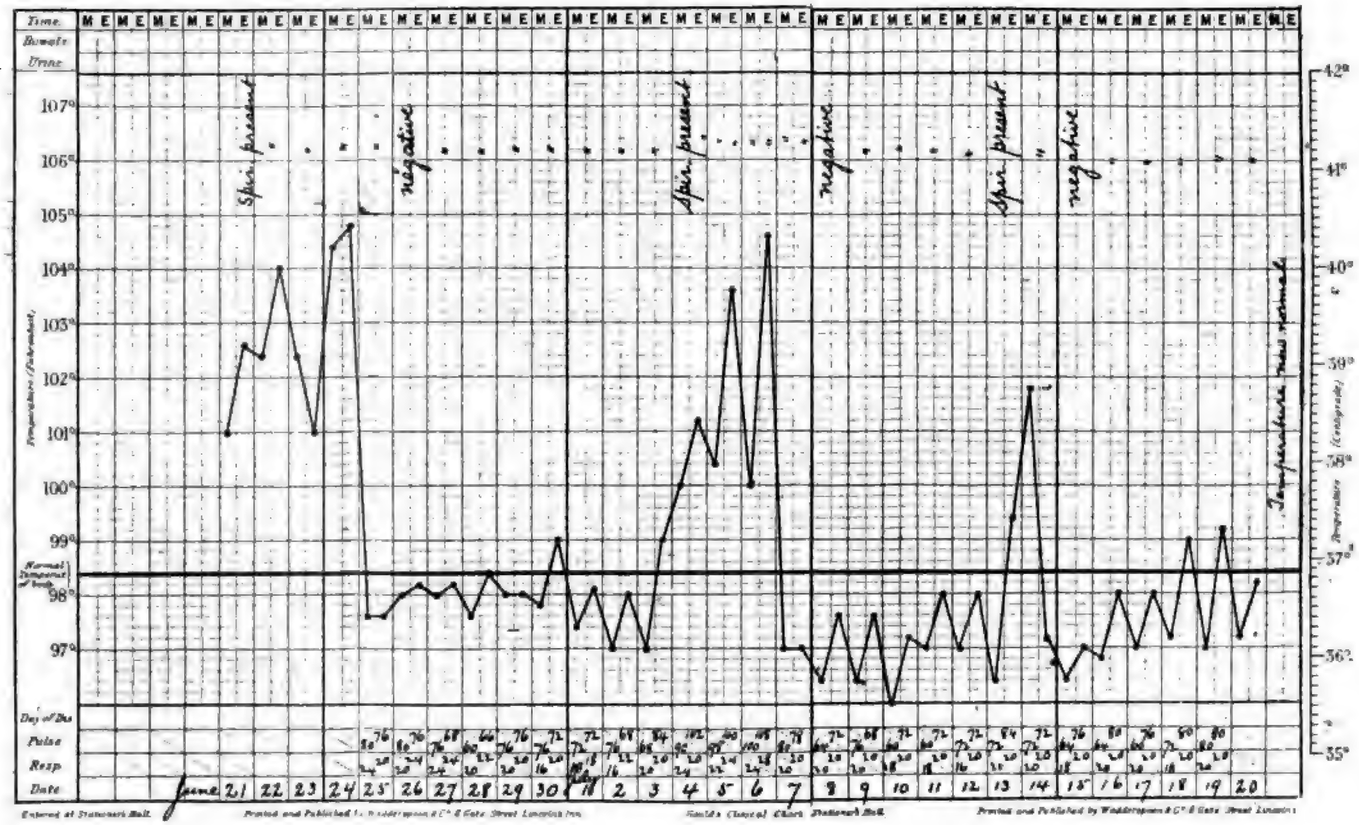
Name J. Fa.

Age

Diet

Case Book No.

Chart 2.



Date of admission

Result

made at this time revealed the presence of fairly large numbers of parasites (1 to 4-5 fields).

The physical examination showed slight enlargement of the spleen, which could be palpated 2·5 cm. below the costal margin. Other than this, nothing abnormal could be found.

On Sunday evening the crisis occurred, preceded by a pseudocrisis on Saturday, and accompanied by heavy sweats. The following morning he was much better, but still felt some malaise, and was then removed to the care of Dr. J. Hill Abram.

We are indebted to Dr. Abram for the following notes from the records of the Royal Infirmary, Liverpool:—

June 25th, 1906.

Circulatory system.—Pulse 60, regular, good volume, tension rather low. Artery wall not thickened.

Cardiac impulse felt in Vth space, 6 cm. to the left, localized, regular.

Second pulmonary sound, slightly accentuated.

Abdomen.—Liver not enlarged. Spleen can be felt 2·5 cm. below costal margin. Tongue slightly coated.

Urine.—Alkaline, deposit of phosphates. No albumen.

After admission to the hospital the malaise gradually passed off. The temperature after the crisis remained below normal until the 3rd of July, when the first relapse set in with the usual symptoms—headache and pain in the bones and spleen. The relapse lasted three days and ended by crisis preceded by a pseudocrisis, and the patient was free from any symptoms until a week later, when a second relapse occurred of twenty-four hours' duration. The symptoms were very slight in this relapse, which was the last.

The treatment was wholly symptomatic.

The etiology of this case is not very clear. The disease is highly infectious, and the patient may have become infected through the bites of animals suffering from spirochaetal infection. In this event the parasites would pass directly from abrasions in the gums to the bite, and not from the saliva. We have never been able to see spirochaetes in the saliva of infected animals which resembled those in the blood, and the inoculation of saliva into rats was never followed by the appearance of spirochaetes in the blood.

Subinoculations.—One monkey, Experiment 1,227, was inoculated with 2 ccm.

of citrated blood during the crisis of the first attack and became infected after an incubation period of five days. The attack lasted three days and was followed by a relapse nine days later.

Two rats, Experiment 1,228, inoculated intraperitoneally at the same time with 3 and 2·5 ccm. of citrated blood respectively, became infected after incubation periods of one and three days and passed through the usual course of infection.

On the 26th June two other rats, Experiment 1,230, were inoculated intraperitoneally with 3·5 and 3 ccm. of citrated blood in which no spirochaetes could be seen. They became infected after incubation periods of three and four days.

CASE III (Chart III)—J. Fd., age 14. Felt ill for the first time on the evening of August 5th, when he fainted and afterwards vomited. At this time his temperature was normal, but had risen to 104° F. on the following morning. The attack was accompanied by all the usual symptoms—severe headache, pains in the bones and especially the spleen, complete anorexia and great thirst. Spirochaetes were found in the blood on Sunday (1 to 5 fields). The patient was removed to the Northern Hospital on August 7th, and we are indebted to Dr. W. B. Warrington for placing the records at our disposal. The disease in this case followed the ordinary course; the relapses occurred at the usual intervals, and were accompanied by a recrudescence of the original symptoms. During the first relapse the patient vomited very frequently, but this was the only remarkable feature of the case.

The etiology of this case is obscure. As in Case II, the only possible mode of infection seems to be the bites of infected animals.

IV. A Clinical Comparison of African Tick Fever and European Relapsing Fever

Koch, in his "Ergebnisse einer Forschungsreise nach Ostafrika,"[12] has drawn attention to the shortness of the attacks in tick-fever and to the small number of parasites in the blood in comparison with the European relapsing fever. We have been able to confirm these observations in the few cases which we have seen ourselves, and also by a reference to those of Dutton and Todd. The statistics of European relapsing cases show that the attacks and relapses are of longer duration than those of African tick-fever.

Hödlmoser[10] observed in only 1·1 % of his cases attacks with a duration of three days, in 5 % a duration of four days, and in 60·5 % the duration of the attacks was from six to eight days.

DISEASE.

Tick Fever.

Notes of Case

Name J. F.

Age 14

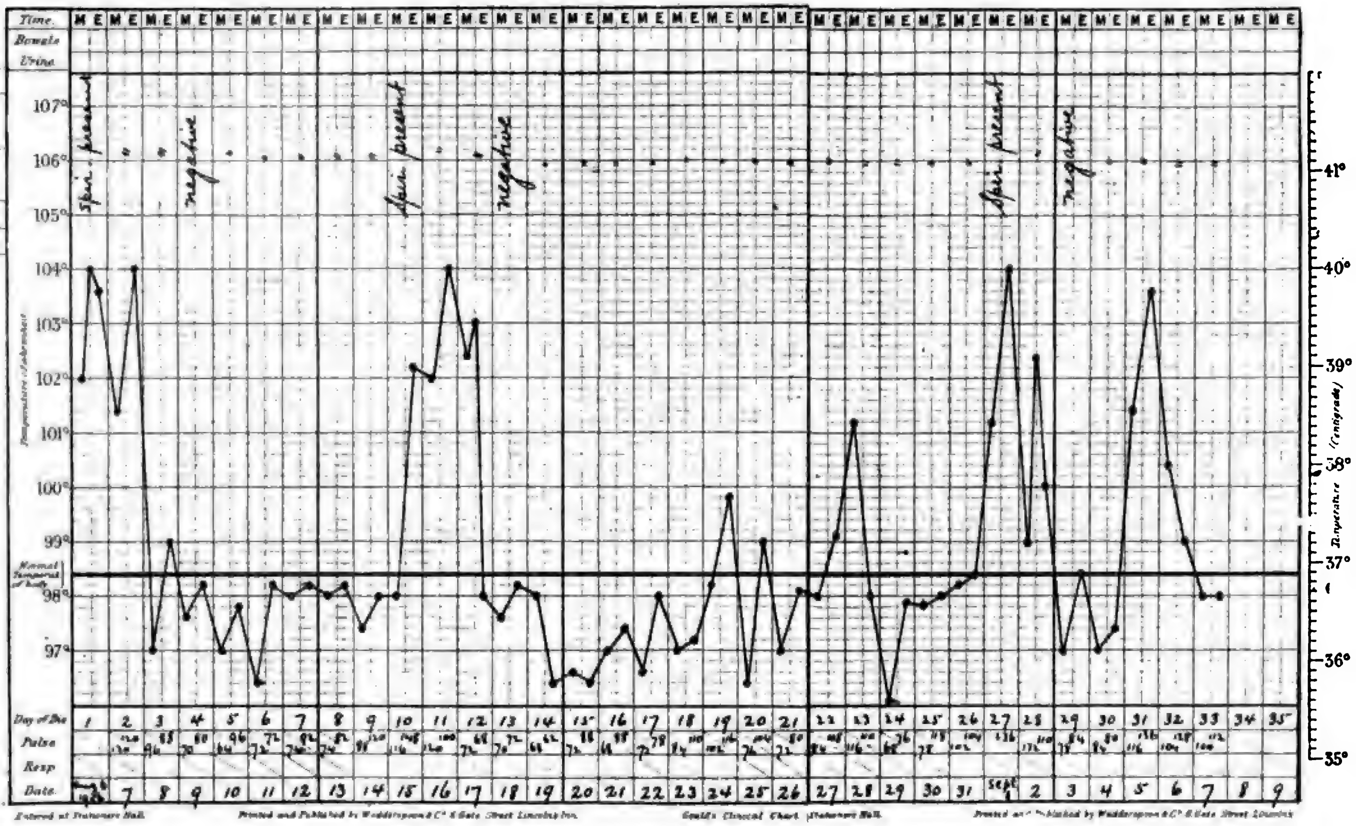
Diet

Case Book No.

Chart 3.

Date of admission

Result



No. of Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14
In I attack per cent. of patients	—	—	1·1	5·0	6·5	21·2	19·1	20·2	9·7	7·9	4·5	2·5	2·2	0·4
II	11·3	10·6	16·9	2·5	27·5	7·5	0·6	—	—	0·6	—	—	—	—
III	2·5	2·5	2·5	10·7	10·7	—	3·6	—	—	—	—	—	—	—

The following table gives the observations of Moczutkowsky[18]:—

	Duration in Days				
	I	II	III	IV	V
Attacks	$6\frac{3}{4}$	$5\frac{1}{2}$	$3\frac{1}{4}$	$2\frac{1}{8}$	1
Intervals	$5\frac{1}{4}$	6	9	$10\frac{1}{2}$	—

Meschede[15] gives the following averages:—

	Duration in Days				
	I	II	III	IV	V
Attacks ...	7-6	5-4	4-3	3-1	1-0
Intervals ...	7-8	9-10	11-12	—	—

and Oks[27]:—

	Duration in Days		
	I	II	III
Attacks	5·7	3·8	2·0
Intervals	6·6	4·3	—

The length of the first attack was four days in the three cases given in detail above, in a fourth which has not been published as it does not differ from those described, and in Case No. VI of Dutton and Todd (J.E.D.). In the other cases quoted in their report the first attack was not carefully observed from the beginning except in one, J.L.T., in which the attack lasted three days.

No conclusions can be drawn as to the length of the intervals and the number of relapses in tick-fever, as the cases observed have been too irregular in their course and too few in number. Slight prodomal symptoms of malaise may occur, but in our cases the disease set in suddenly with headache, pain in the spleen and bones, and vomiting. Diarrhœa is frequently noticed just before the attack. Although

no distinct chills occur, the patients complain of feeling very cold. Coincidently with the commencement of the infection the spleen becomes enlarged and tender, and the very intense and agonising pain felt in this region was in our cases the most characteristic symptom of the disease. During the attack there is complete loss of appetite and great thirst, and a slight degree of bronchitis is common. The fever falls by crisis, and during this period the patients sweat profusely. In the intervals no morbid symptoms are apparent.

The peripheral blood was examined every day in our cases, and the maximum number of spirochaetes observed was two to three per field at the height of the attack.

V. Animal Reactions of Sp. duttoni

In a preliminary report [4] we have published notes on the reactions of spirochaetes observed in various animals. Since then these have been amplified and completed.

Monkeys

Many monkeys, of different species, were used in the course of the experimental study. The susceptibility to the disease varied greatly with the species and with the age. We have found young Mona (*Cercopithecus mona*) and young Callithrix (*Cercopithecus callitrichus*) monkeys most susceptible to the infection, followed by Rhesus (*Macacus rhesus*), "Sooty" (*Cercocebus fuliginosus*), "Jew" (*Cercopithecus?*) monkeys and baboons (*Papio anubis*) in the order named. The resistance to infection increased with the age. While this is true in general, some animals showed a decided idiosyncracy to the disease, and succumbed very rapidly even when inoculated with small amounts of infected blood. The condition of the monkey at the time of inoculation also had an influence on the course of the disease, which was of a more severe type in the animals which were not in perfect health. All of our monkeys, with a single exception, became infected.

This was a large female Rhesus of 1,800 grms. weight, Experiment 1,272. It was inoculated with 7 ccm. of heavily-infected citrated blood from two rats, and in spite of careful bi-daily examinations no parasites were found during the next eight days. It was then reinoculated with 8 ccm. of citrated blood showing 60-80 parasites to a field, with the same result.

Vandyke Carter,[7] in his classical work, records the same result in

DISEASE

Notes of Case

Name MONKEY EXP. 1227

Age

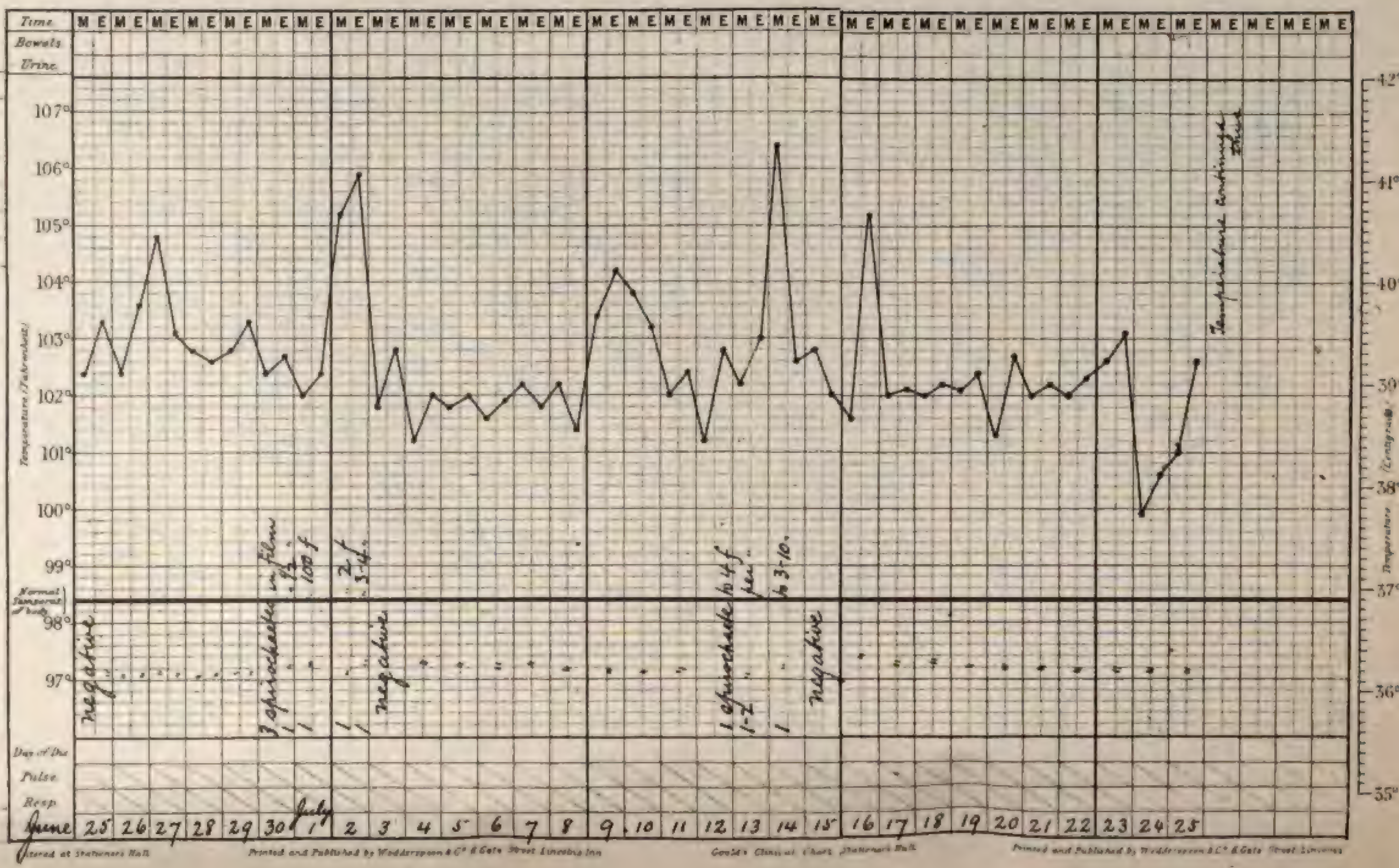
Diet

Case Book No

Chart 6

Date of admission

Result



DISEASE.

Notes of Case.

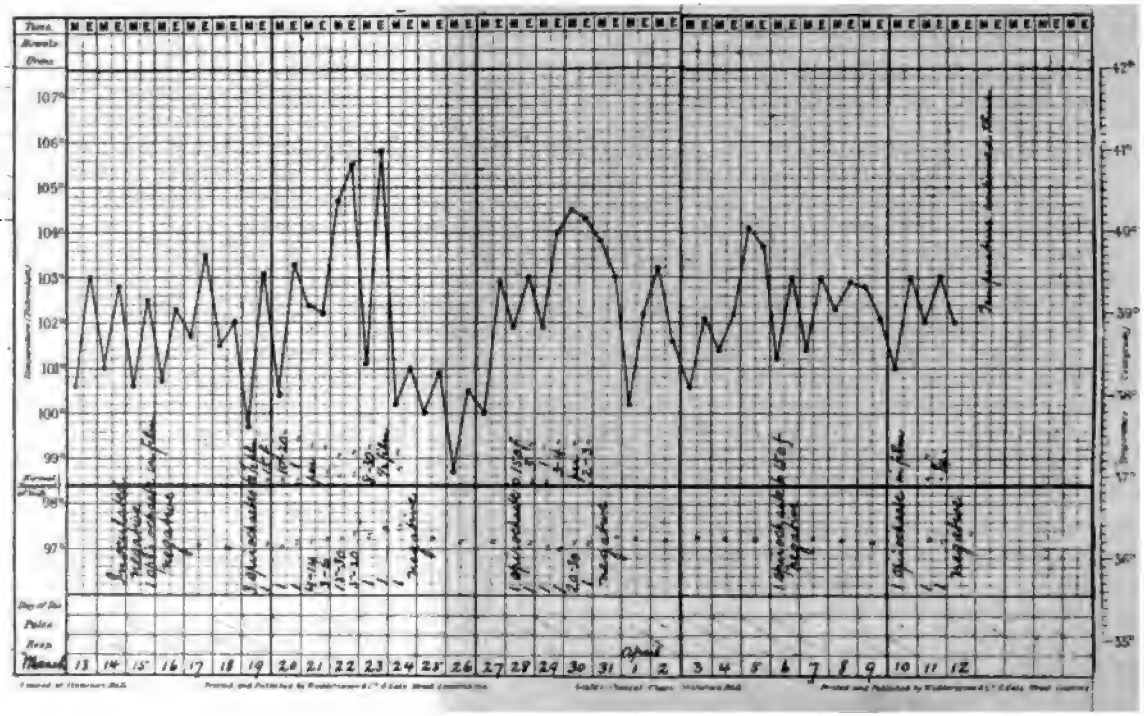
Name MONKEY EXP. 1058

Age

Diet

Case Book No

Chart 5.



Date of admission

Result

DISEASE.

Notes of Case.

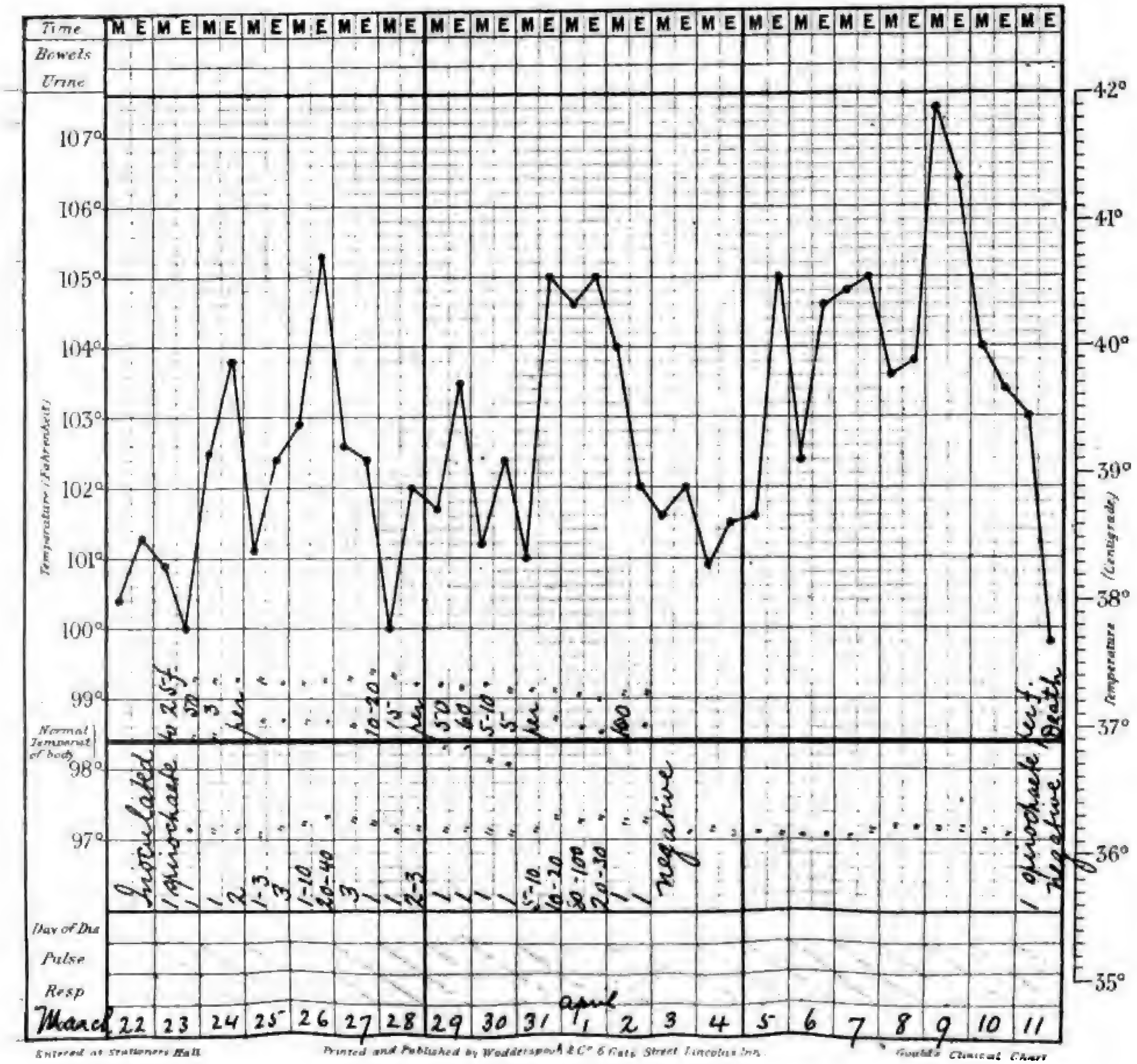
Name { MONKEY EXP. 1063

Age

Diet

Case Book No

Chart 4.



Date of admission

Result

the case of two monkeys with the spirochaete of Indian relapsing fever.

The incubation period varied, as in rats, with the quantity of spirochaetal blood injected. When from 5-10 ccm. of infected blood was used, the parasites appeared in the peripheral blood within two hours; when smaller doses were employed, at times varying between two hours and three days. The parasites were found, at first, in very scanty numbers, increased slowly, and in two or three days were fairly numerous, so that in some cases they could not be counted. When the increase occurred very quickly the parasites disappeared, as a rule, very rapidly, and within one or two days the peripheral blood did not contain any. When, on the other hand, the increase was very slow, the spirochaetes did not disappear promptly but were present in the blood stream for a much longer period, up to twelve days in one case. Again, when the parasites became innumerable and remained present in the peripheral blood in such a number for two or three days, the death of the monkey was a foregone conclusion.

Coincidently with the appearance of the parasites the temperature rose, and during the course of the attack went as high as 107° F. in some cases (Charts IV, V and VI). It fell with the decrease in the number of parasites, but even when these were completely absent from the peripheral blood the temperature remained of a more or less irregular type. With the commencement of the relapse there was usually a distinct rise in the temperature again.

When the temperature fell markedly, with numerous spirochaetes in the blood, it could be regarded as a sign of approaching death. In these cases the temperature became subnormal, and remained low until the animal died. The height of the temperature did not always correspond to the number of spirochaetes in the blood, as the parasites were sometimes present in monkeys with normal temperatures.

After the disappearance of the spirochaetes, none were observed in the peripheral blood, as a rule, until the next relapse, which occurred at varying intervals after the attack. In typical cases of the disease, the relapse was ushered in by a rise of temperature, and the spirochaetes were found at the same time. When the first attack was of a severe type the relapse was milder in character, and *vice versâ*. One or two relapses were observed in most of the cases,

though frequently three occurred. Abortive relapses were also noted, *i.e.*, the temperature rose for a short time but spirochaetes were not found in the blood preparations.

The disease lasted from three days to eight weeks, counting from the first appearance of the parasites until the last day on which they were found.

When the infection was caused by the bites of ticks, the incubation period varied between five and seven days, five being the commonest. The course of the disease was identical with that observed after the inoculation of blood containing spirochaetes.

The monkeys suffered more or less from the disease. Usually with the appearance of the parasites the animal became quiet and listless, did not eat, and remained crouched up. In some cases, however, the monkeys showed no change in appearance and ate as in health. Loss of weight was observed as a general rule. During the infection a loss of from 200-400 grammes was noted, but on recovery this was quickly regained. A very marked feature was the anæmia which occurred. When the ear was cut for the purpose of making preparations, the blood was very pale and watery and did not coagulate as rapidly as normally. The blood counts revealed a noticeable decrease in the number of red cells, together with a marked fall in the percentage of haemoglobin. The number of leucocytes varied with the stage of the disease. At the commencement of the attack there was a slight increase in the number of white cells, and this continued until the spirochaetes were about to disappear, when a marked leucocytosis was observed, as many as 60,000 white cells being counted in one case.

At the autopsy made on monkeys dying of the disease, the heart muscle was degenerated. A varying quantity of clear transudate was found in the pleural and pericardial cavities. Small subpleural petechiae were commonly seen. The lungs were oedematous, and exhibited haemorrhagic infarcts. The peritoneal cavity frequently contained transudate. The liver was usually enlarged, congested and showed small haemorrhagic areas throughout the substance. When the disease had lasted some time before the monkey died, small necrotic areas were found. Of all the organs the spleen was most markedly changed. It was enlarged, as a rule, to twice or thrice its usual size, deeply congested

and very soft. Sometimes the surface was uneven and coarsely granular. These granules extended into the underlying tissue, and were composed of rounded necrotic areas of whitish colour intermingled with small haemorrhages. In acute cases numerous haemorrhagic infarcts were found scattered through the whole organ, occasionally involving half its extent. As in the liver, necrotic areas of varying size were commonly seen in cases of longer duration. The Malpighian bodies were enlarged and of a greyish-white colour. The other abdominal organs showed only some congestion. The lymph glands were frequently haemorrhagic. The marrow of the long bones was of a dark purple colour and softened to a semi-fluid consistence. Throughout its substance small greyish necrotic areas were often seen. The brain and spinal cord showed some congestion of the superficial vessels. Films were made from all the organs, and were examined in order to see whether the spirochaetes showed a predilection for any one organ. Whilst the number of parasites found in the spleen and bone marrow was far less than that observed in the blood, approximately the same number was found in the other organs. These pathological changes correspond to those found by Ponfick[28] in human cases of European relapsing fever.

Subinoculations from monkeys were made into rats at different stages of the disease. The blood was infective, not only when the spirochaetes were present in the peripheral circulation but also in the interval between the relapses. In the latter case, however, the incubation period in the rats was prolonged and the infection was of a milder type than usual.

Dogs

Experiment 1,018, mongrel, was inoculated intraperitoneally with 15 ccm. citrated blood showing 60-80 parasites per field, and spirochaetes were found in blood preparations two hours later (1 to 10 fields). With the appearance of the spirochaetes the temperature rose and on the second day had reached 103·8° F. and then fell to normal by the fourth day. A marked leucocytosis occurred with the appearance of the parasites. The number of parasites increased very slowly until the next evening when 2-3 per field were counted in fresh specimens of the blood. In the afternoon of the third day one parasite to 20-25 fields, in stained preparations, was found but three hours later the spirochaetes had disappeared and were not seen again.

Experiment 1,054, pup, four months old. Inoculated intraperitoneally with 13 ccm. of almost pure blood from a heavily-infected rat. Spirochaetes were present in the blood for the next two days, but always very scantily (1-2 per film) and then disappeared finally.

Experiment 1,053, pup of same litter. On February 24th, 41 young infected ticks were fed on this dog. As parasites were never seen in preparations up to March 22nd, 49 ticks were then fed again, but without result.

Cats

Four cats were inoculated with large amounts of heavily-infected blood, but spirochaetes were never seen in preparations of the peripheral blood.

Horses

One pony, Experiment 1,019 (Chart VII), was inoculated intraperitoneally with 27 ccm. of citrated, heavily-infected blood from two rats. The mixture showed 5-20 parasites per field. The blood was examined every two hours after the inoculation, and parasites were found for the first time seven hours afterwards (4 to ¼ film). The number increased up till the evening of the next day, when as many as 2 spirochaetes to a field were observed, and then decreased until, on the third day, the examination proved negative. Although examined twice daily no spirochaetes were seen again in the blood until the ninth day, when in the morning film one spirochaete was found. The preparation made in the evening did not contain any parasites.

Later a rise of temperature occurred, but no parasites were seen in the blood preparations, and subinoculations into rats were not followed by infection, although heavy doses were used (10 ccm. citrated blood).

Goats

One goat, Experiment 1,058, was inoculated intraperitoneally with 50 ccm. citrated blood from heavily-infected rats. The mixture showed 2-3 spirochaetes per field. A slight rise of temperature from 102·5° F. to 103·6° F. was observed on the evening of the inoculation. Parasites were never found in preparations of the blood, but a rat inoculated with 10 ccm. of citrated blood from the goat on the third day became infected after an incubation period of two days. The attack lasted nine days, and was followed by three relapses. Another rat was inoculated seven days after the inoculation of the goat, but without result.

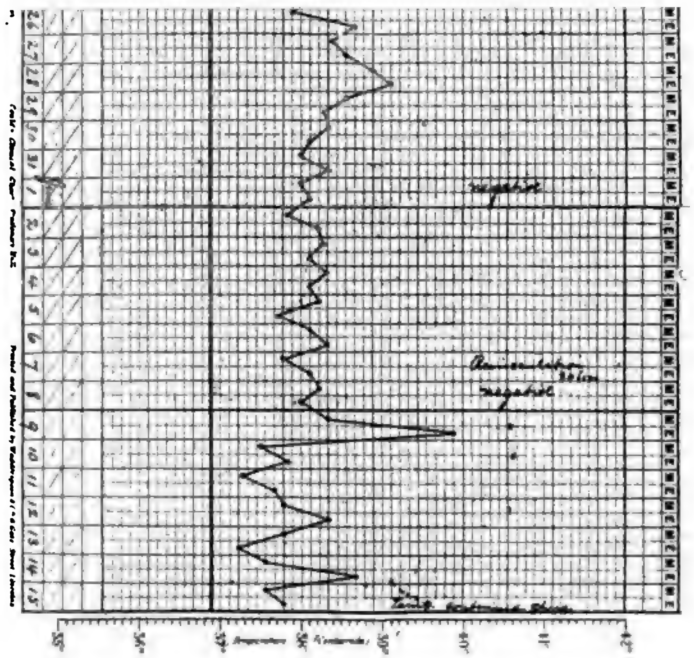
Sheep

One sheep, Experiment 1,150 (Chart VIII), was inoculated intraperitoneally with 50 ccm. of citrated blood containing 10-20 spirochaetes per field. Parasites were found in preparations of the blood made on the same evening (4 to a film) coincidently with a rise in temperature, and then disappeared. Two days later a rat was inoculated from the sheep, and became infected after an incubation period of eight days.

Rabbits

From our experiments, it seems that the spirochaetes when inoculated in doses of more than 5 ccm. are very pathogenic for rabbits. Small doses do not seem to have any effect.

Many adult rabbits were inoculated, in every case with a fatal issue when a dose of 4 ccm. or more was employed. As a rule, spirochaetes in very small numbers were found in preparations of the



Date of admission. ....

Result ....

Day of Ills																				
Pulse																				
Resp																				
D May	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

35°

Entered at Stationers Hall *Printed and Published by Wodderspoon & C° 6 Gate Street Lincolns Inn* *Gould's Clinical Chart*

DISEASE.

Notes of Case.

Name { SHEEP EXP. 1150

Age

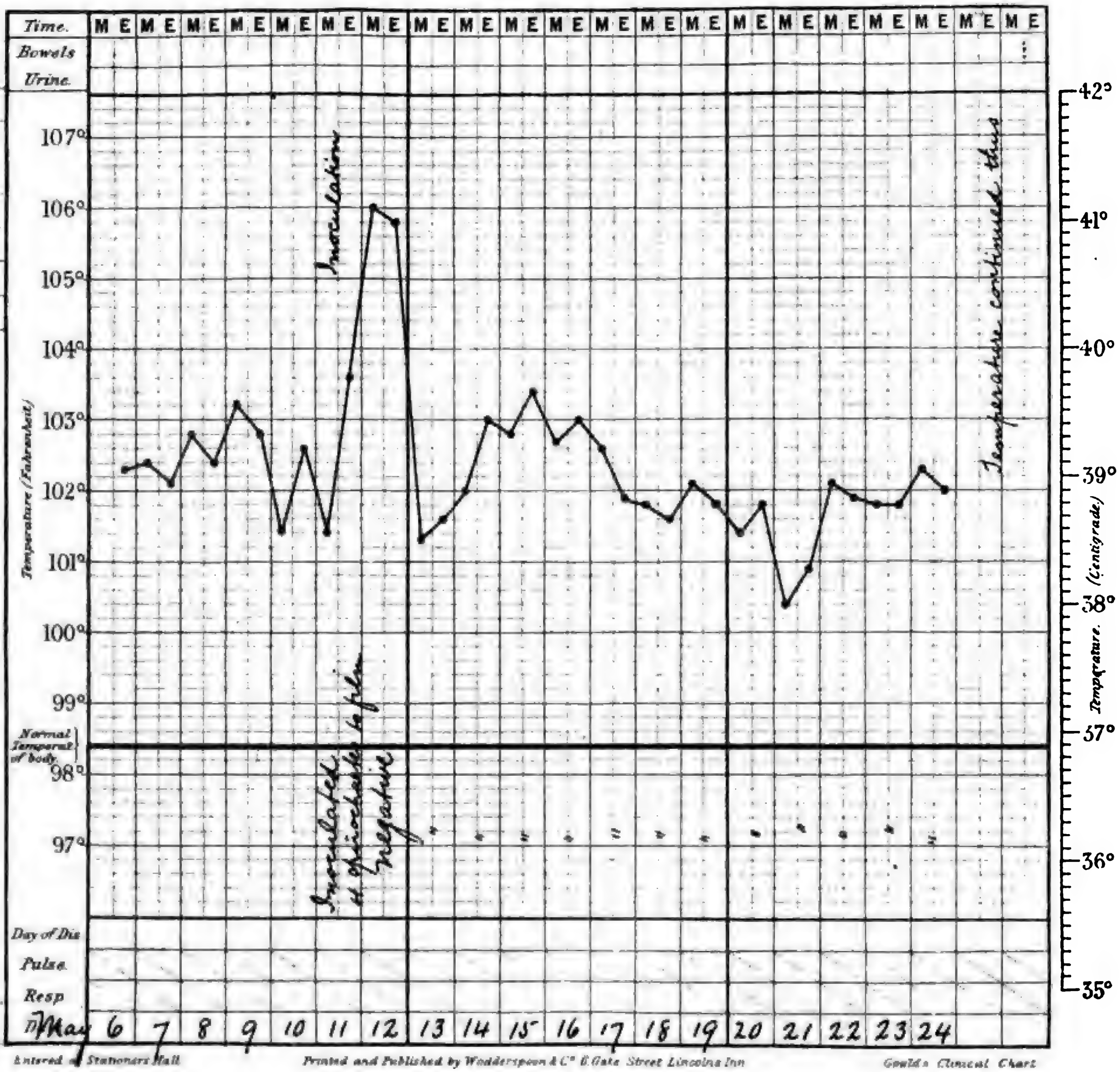
Diet

Case Book Nº

-Chart 8.

Date of admission.

Result



DISEASE.

Notes of Case.

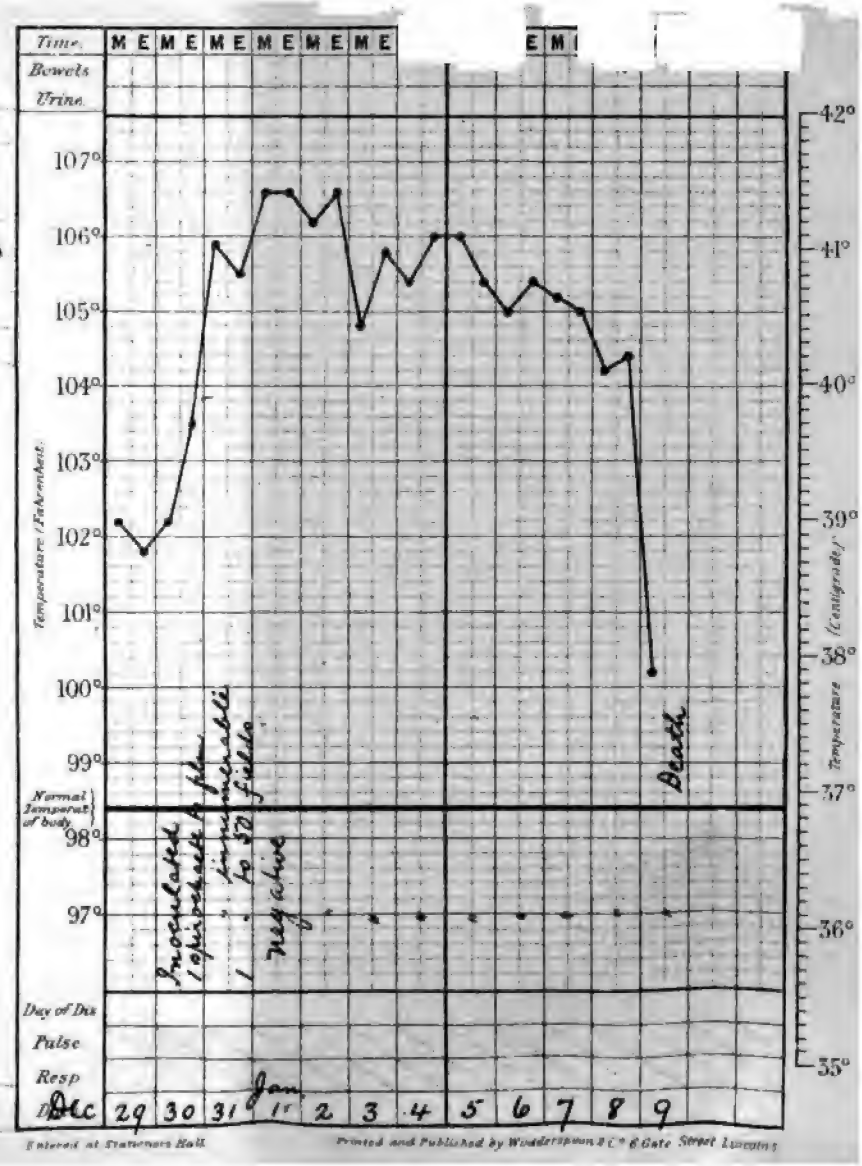
Name { RABBIT
EXP. 995A

Age

Diet

Case Book No.

Chart 9



Date of admission

Result

peripheral blood two or three hours after the inoculation. At the same time a marked rise of temperature occurred (see Chart No. IX). The parasites usually multiplied during the next few hours and then gradually decreased. In preparations of the peripheral blood made at this time degenerating forms were seen. A second increase in the number of parasites then followed until, after seven or eight hours, from one to three per field could be counted in fresh blood preparations. In a few cases the blood was simply swarming with spirochaetes. They were present in the peripheral blood for from 1-3 days and then disappeared finally. A leucocytosis of the polymorphonuclear type set in with the appearance of the parasites. Spirochaetes were found in the peritoneal fluid withdrawn twelve and fourteen hours after inoculation, but no leucocytosis or phagocytosis was seen. The temperature usually remained high, on occasions even rising to 107° F. The animals appeared to be very sick, remained constantly in one corner of the cage, did not eat at all and emaciated rapidly. At the same time mucous discharges from the rectum and intractable diarrhœa were noticed. During the course of the disease the rabbits suffered from a progressive anæmia. The blood became very watery, and the coagulability was greatly lessened. In from three to ten days death supervened.

In very young rabbits (eight weeks old) the disease was of much shorter duration than in adult ones. The parasites appeared in the blood shortly after the inoculation, and were present for from two to three days. The animals usually died on the fourth day without any previous symptoms.

At the post-mortem examination few changes were found in the thoracic viscera. The pleural sacs occasionally contained a small quantity of exudate poor in cellular elements, the lungs showed small subpleural petechiae and the heart was soft and flabby. Very rarely exudate was found in the peritoneal cavity. The liver was slightly enlarged, showed small superficial haemorrhages which sometimes involved the underlying tissue, and in two cases small necrotic infarcts. The spleen was more or less enlarged—in one case $10 \times 2{\cdot}5 \times 1{\cdot}5$ cm.—deeply congested, very soft and of a dark purplish-red colour. The Malpighian bodies were very prominent and greyish-white in colour. In some cases haemorrhagic infarcts from 1 to 5 mm. in diameter were found, while in others numerous small, whitish,

necrotic areas were scattered throughout the spleen substance. The bone marrow was very soft, and scattered through the reddish marrow were numerous greyish areas.

Subinoculations were made in rats with various amounts of blood, up to 6 ccm. Usually, the rats became infected only when spirochaetes were seen in the rabbits' peripheral blood. In one case subinoculations were made on the day of the rabbit's death, four days after inoculation, and the rat became infected after an incubation period of eight days.

Guinea-pigs

In guinea-pigs the course of the disease was much the same as observed in rabbits, but a fatal termination was less common. The incubation period varied between two hours and three days, depending on the amount of blood used for inoculation, and the parasites were found in the peripheral blood preparations for two to three days before they finally disappeared. In the small percentage of guinea-pigs which died, the only changes observed at the autopsy were sub-pleural haemorrhages and enlargement of the spleen.

Very young animals were more susceptible than adults.

Subinoculations in rats were followed by infection only if made when the guinea-pigs showed spirochaetes in preparations of the blood.

Rats

Rats are very susceptible to the disease, young ones more so than adults. Of the total number used in the work, only two displayed a remarkable resistance against infection.

One of these never became infected, although inoculated twice with large amounts of spirochaetal blood. The other remained negative after an injection of 8 ccm. of infected blood, but showed the parasites for two days when inoculated five days later with a second dose of 7 ccm.

The incubation period varied directly with the amount of infected blood injected and with the mode of inoculation. When small quantities were used—up to 2 ccm.—spirochaetes were found in the peripheral blood in small numbers within from twelve to twenty-four hours after the inoculation, while when larger doses were injected—up to 5-10 ccm.—the spirochaetes were found two hours later. Very occasionally the incubation period was much prolonged—up to twenty-one days in one case. Rats inoculated subcutaneously became

infected a few hours later than those receiving the injection intraperitoneally. The parasites multiplied more or less rapidly, depending on the dosage, and on the second day from 20-30 per field were seen in the blood preparations. On the following day they were numerous and on the fourth day innumerable, as a rule, *i.e.*, the whole field was densely covered with the spirochaetes. In the majority of the animals a marked leucocytosis was observed later on the fourth day, and with this the spirochaetes commenced to decrease in numbers. Their diminution at this period was followed out by hourly examinations of rats, and one of these experiments may be quoted.

When the examination was begun at 2 p.m., from 60-70 parasites, and 20-25 leucocytes per field were counted. The leucocytes were chiefly of the polymorphonuclear type, and many of them contained large granules, and occasionally erythrocytes. The parasites were very active and appeared perfectly normal. This condition continued up till 9 p.m. with hardly any change except that the spirochaetes, in freshly drawn blood, did not appear to be quite so active. At 9 o'clock the leucocytes had increased markedly (30-35 per field), and many of them contained dark, irregular inclusions and large granules. The spirochaetes for the most part were normal in appearance, but a few were fastened to the slide at either end, and in these the spirals moved very slowly and jerkily from side to side. At the same time a slight change in the form of a few parasites was seen. A small, rounded or oval, translucent body was observed at the side and towards the middle of the spirochaete, and moved longitudinally and laterally in unison with the parasite. The rapidity with which many of the spirochaetes ceased moving in freshly drawn blood was very marked. Whereas at the commencement of the examination most of the spirochaetes were active, half an hour later a very large number were absolutely motionless. This was all the more noticeable as the parasites in preparations of blood made from an animal at the height of an attack usually retained their activity unchanged for hours.

At midnight the number of leucocytes was smaller. From the first, many of the spirochaetes were motionless, and very many more ceased moving within the next fifteen minutes. From 10-15 parasites per field were counted. In preparations kept in the incubator (37° C.) hardly any phagocytosis was observed—only two or three leucocytes were seen engulfing the spirochaetes during the whole period of observation.

Until two o'clock the parasites had decreased in number very slowly, but after this time there was a decided and sudden fall in number observed. At 3 a.m. only 3-4 per field were counted, at 5-30 only one spirochaete to about 150 fields was seen, and in the thick stained specimen of blood made at 9 a.m. only three spirochaetes were found. During the period in which the rapid diminution occurred, viz., from 2 to 5-30 a.m., a greater number of the spirochaetes than observed earlier had the central rounded bodies mentioned above, while many of the parasites were much more irregular in outline than normal, presenting at intervals along their bodies slight thickenings. In others, which were normal in shape, small, well-defined, translucent dots were seen.

As a rule, the attack lasted five days, but spirochaetes have been seen in the peripheral blood for fifteen consecutive days. When the

spirochaetes were about to disappear, after the height of the attack was reached, a peculiar phenomenon was seen frequently in fresh blood —irregular clumps composed of large numbers of entangled parasites and red blood cells.

After the attack the spirochaetes disappeared from the peripheral circulation, and even to the most careful examination (four preparations in one day) the blood was negative. In from three to eight days a relapse occurred, but was of shorter duration than the original attack, and during it the examination at no time revealed the presence of the spirochaetes in so great numbers as seen during the attack itself. A second, third and even a fourth relapse, at varying intervals, was observed, each less severe than the previous one and with fewer parasites in the peripheral blood until, in the fourth, only one in a film was seen. The total duration of the disease varied between three and forty-five days.

While this was the typical course of the disease, variations were observed. Fairly often after the number of parasites had increased to the maximum in the manner indicated they did not diminish, but remained constantly present in very large numbers until the rat died in the course of two or three days. In other cases, in which the amount of blood inoculated was small or was from an animal in whose peripheral blood no parasites could be seen, the spirochaetes increased in number very slowly and were never very plentiful. In these rats the first relapse was more severe than the attack, and during its course the spirochaetes were much more numerous than in the attack.

After the inoculation the symptoms observed were usually very slight. The rats did not show any change, but when the attack was at its height some became drowsy and remained huddled up in one position. Frequently, however, the rats appeared absolutely normal, being very lively and eating freely. Loss of weight during the infection was common and there was also an anæmia corresponding in degree to the severity of the infection. After the final disappearance of the parasites, rapid recovery ensued. In the cases followed by a fatal termination the rats passed from a drowsy to a semi-comatose condition. To the touch they were quite cold, and the thermometer did not register. A very common feature was diarrhœa, and rarely haematuria was observed, even when very

small doses of rat blood were used for inoculation. Just before death clonic contraction of the muscles of the legs was observed, and sometimes paraplegia.

Attempts to get the temperature curve of the disease in rats were without result, as it was very irregular and bore no relation to the presence of spirochaetes in the blood.

While we have been unable to infect guinea-pigs and rabbits through the bites of infected ticks, this method succeeded perfectly in the case of rats. The incubation period was from 5-7 days, and after this time the spirochaetes appeared in the peripheral blood in scanty numbers, but were never seen in nearly so great a number as was observed after inoculation. The first attack was usually of prolonged duration, and was followed by two to three relapses. On the whole, the course of the disease in rats infected by tick-bites was milder than in those infected by direct inoculation.

The post-mortem appearances in the rats dying of the infection were much the same as in other animals which died from the disease. The mediastinal connective tissue was gelatinous. In the pleural and pericardial cavities a varying quantity of clear fluid was often found. The lungs were oedematous, and sometimes contained small haemorrhagic infarcts. Small subpleural petechiae were seen. The heart was pale and soft. The liver was enlarged slightly, contained small haemorrhagic infarcts, and in those cases in which the disease had lasted for some length of time, anæmic infarcts of different sizes. The spleen, in the acute cases, was usually very much enlarged (sometimes measuring 6 × 2 × 1·5 cm.), of very dark colour, and contained haemorrhagic infarcts of varying size. In cases of longer standing anæmic infarcts were observed. The Malpighian bodies were enlarged and grey in colour. The lymph glands were unchanged macroscopically. The bone marrow was very soft and congested.

MICE

The course of the disease in these animals was identical with that observed in rats, but mice succumbed more readily to the infection. The changes in the organs, at the post-mortem, were also similar in character to those observed in the rats.

All attempts to infect chickens, pigeons, and goldfish with *Spirochaeta duttoni* have proved negative.

The above experiments show that we have been able to infect nearly all the usual laboratory animals with *Sp. duttoni*, i.e., monkeys, dogs, horses, goats, sheep, rabbits, guinea-pigs, rats, and mice. In some the parasites were found only in the subinoculations. Cats have shown themselves to be entirely refractory to the infection. The most susceptible animals, in our experience, are white rats and then monkeys.

RAT, EXPERIMENT 994
Inoculated December 30, 1905

Date	Day of Disease	No. of Parasites	Leucocytes
Dec. 30	1	ev. 1 to 150 f.	
,, 31	2	1 to 3 f.	
Jan. 1	3	m. 1 to 1 f. e. 30 to f.	
,, 2	4	Negative	Very numerous
,, 3	5	,,	Decreasing
,, 4	6	3 to ¼ film	Normal
,, 5	7	Very numerous	Numerous
,, 6	8	,,	Decreasing
,, 7	9	1 to 100 f.	
,, 8	10	5 to film	
,, 9	11	1 to 80-100 f.	
,, 10	12	2 to film	
,, 11	13	1 to 100 f.	
,, 12	14	2 to film	
,, 13	15	Negative	
,, 14	16	,,	
,, 15	17	,,	
,, 16	18	,,	
,, 17	19	,,	
,, 18	20	,,	
,, 19	21	,,	
,, 20	22	,,	
,, 21	23	,,	
,, 22	24	,,	
,, 23	25	1 to 3-8 f.	
,, 24	26	3-7 to f.	
,, 25	27	1 to 180 f.	
,, 26	28	1 to film	
,, 27	29	Negative	
,, 28	30	1 to 6-22 f.	
,, 29	31	Negative	
,, 30	32	,,	
,, 31	33	1 to 10-70 f.	
Feb. 1	34	1 to 20-25 f.	
,, 2	35	1-2 per f.	
,, 3	36	Negative	
,, 4	37	,,	
,, 5	38	,,	
,, 6	39	,,	
,, 7	40	1 to 150 f.	
,, 8	41	1 to 5-35 f.	
,, 9	42	2 in film	
,, 10	43	Negative	
,, 11	44	,,	

RAT, EXPERIMENT 990B
Inoculated December 26, 1905

Date	Day of Disease	No. of Parasites
Dec. 27	2	Numerous
,, 28	3	Innumerable
,, 29	4	,,
,, 30	5	,, Death

RAT, EXPERIMENT 1022
Inoculated January 17, 1906

Date	Day of Disease	No. of Parasites
Jan. 17	1	Negative
,, 18	2	,,
,, 19	3	1 to 30-40 f.
,, 20	4	6-7 per f.
,, 21	5	5-6 per f.
,, 22	6	1 per f.
,, 23	7	1 per 60 f.
,, 24	8	1 per 5 f., 2 to 1 f.
,, 25	9	3 per 1 f., 1 to 3 f.
,, 26	10	Negative
,, 27	11	,,
,, 28	12	1 to 10-15 f.
,, 29	13	1 to 150 f.
,, 30	14	Negative
,, 31	15	1 in film
Feb. 1	16	1 to 7-9 f.
,, 2	17	2 to 1, 1 to 3 f.
,, 3	18	Negative
,, 4	19	,,
,, 5	20	,,
,, 6	21	,,
,, 7	22	,,
,, 8	23	,,
,, 9	24	,,
,, 10	25	,,
,, 11	26	1 in film
,, 12	27	1 to 300 f.
,, 13	28	1 to ½ film
,, 14	29	Negative
,, 15	30	,,
,, 16	31	,,
,, 17	32	,,
,, 18	33	,,
,, 19	34	,,

RAT, EXPERIMENT 1045
Inoculated February 13, 1906

Date	Day of Disease	No. of Parasites
Feb. 13	1	Negative
,, 14	2	,,
,, 15	3	,,
,, 16	4	1 to 50 f.
,, 17	5	5 to 1, 1 to 6 f.
,, 18	6	20 per f.
,, 19	7	Innumerable
,, 20	8	3 to 1 f.
,, 21	9	1-5 per f.
,, 22	10	1 per f.
,, 23	11	1-5 per f.
,, 24	12	10-20 per f.
,, 25	13	20-30 per f.
,, 26	14	20-30 per f.
,, 27	15	5-10 per f.
,, 28	16	Death

VI. Chronicity of the Disease

The disease, once contracted, ran an acute or chronic course. In the latter case the infection was occasionally of long duration; for example, Case I quoted above. In some of the monkeys, *e.g.*, Experiment 199/I infected through tick bites, spirochaetes were seen first on October 13th, 1905, and the monkey died on December 28th, death being preceded by a rise of temperature, during which period parasites were found in preparations of the peripheral blood; none had been seen for the previous six weeks. In another case, Experiment 184/I, the spirochaetes were seen first on February 19th, and were found last on the 13th of May. In rats also the infection was occasionally of long duration. One rat, Experiment 994 (see table), was inoculated on December 30th, 1905, and spirochaetes were seen last on February 9th, 1906. A point which may be emphasised is that a rise in temperature occasionally occurred in monkeys some time after the last evident relapse. Although spirochaetes could not be found in the peripheral circulation at this period, subinoculations into rats were followed by infection after a prolonged incubation period, but the subinoculated rats passed through a very slight attack.

VII. Virulence of the Spirochaetes

In susceptible animals of a given species the course of the disease was usually of a similar type. Some rats died two or three days after the spirochaetes had become extremely numerous in the blood, and it was thought that the strain derived from these might be more virulent, but the rats subinoculated from them did not suffer from a more severe infection than those inoculated with a seemingly less virulent strain. Efforts were made to increase the virulence by passing the spirochaetes quickly through a succession of thirty or forty rats, but this was also ineffectual. The same method practised on young animals, which are distinctly more susceptible to the disease, was without effect. A more or less close relation existed between the number of spirochaetes inoculated and the number appearing in the blood of the subinoculated animal. When blood containing few parasites was used the animal inoculated showed few in its blood, and when heavily-infected blood was injected a correspondingly greater number was observed. When blood was used in which no parasites were seen, obtained from an animal in the interval between

two relapses, the inoculated animal had a slight attack and only few parasites were found in its blood. No difference was noticed in the virulence of strains which had passed through a long series of animals and that derived from animals directly infected through tick bites. The passage of the spirochaetes through man did not lessen the virulence.

VIII. Immunity

A complete list of the literature on immunity in spirochaetal infections was given, first by Wladimiroff in the Handbuch der pathogenen Mikro-organismen,[38] and brought up to date in detail by Novy and Knapp,[24] who believe that they have established "a sound basis for the prevention and cure of relapsing fever and the related tick-fever."[24]

It is a peculiar phenomenon that the spirochaetes disappear from the blood so that they cannot be seen by microscopical examination and then reappear, and the explanations offered are not satisfactory. It is a question whether the disappearance is caused by the formation of a germicidal substance or whether it is characteristic of a life-history of the spirochaete, or is the result of a combination of these two. When fresh preparations were made from an animal during the onset of an attack the spirochaetes lived for some time at the room temperature, and at 37° C.; in both cases a distinct increase in their numbers occurred. The behaviour of the spirochaetes in preparations made during the decline of an attack differed with the temperature at which they were kept. At room temperature the spirochaetes behaved as in the preparations made during the onset, but at blood heat the parasites died in a very short time.

Blood containing numerous spirochaetes, taken on the second or third day of the disease, was mixed with serum obtained from rats which had recovered from the disease in the proportion of 1 : 1 and kept at room and incubator temperatures. Controls were made with normal serum in the same dilution. At room temperature (20° C.) no difference was noted in the appearance of the spirochaetes in the two cases. At incubator temperature the changes in the immune serum specimen were well marked. After a lapse of ten minutes the spirochaetes moved more slowly than usual, and tended to conglomerate with the red blood cells. After half an hour the first dead parasites were seen. Some showed a small oval thickening towards the middle, or occasionally at the extremity, and moved very sluggishly; after an hour and a quarter many of the spirochaetes were still motile, while many others had become entangled in irregularly-shaped masses similar to the appearance observed in the case of *Sp. gallinarum* just before the death of the fowl. Some of these masses were absolutely motionless, but in others the projecting spirochaetes still moved. Lying between the spirochaetes, small,

rounded, refractile granules were seen. At this time the first true agglutination rosettes were noticed. After two and a quarter hours still more rosettes were seen, and only a few actively motile parasites were still present. Five hours afterwards not a single rosette was to be seen, and only very few sluggishly motile spirochaetes; nearly all were clumped together. After seven hours all the spirochaetes were dead. A good number of the spirochaetes preserved their form, even after the lapse of twenty-four hours.

In the control no change in the spirochaetes was seen for the first four hours. After this time the spirochaetes displayed a tendency to clump together, but showed no change in form whatever. Some of them were dead, but living spirochaetes were seen after thirty hours.

When spirochaetal blood was mixed with serum from a hyperimmunised animal in equal parts and kept at incubator temperature (37° C.), many rosettes composed of several hundred spirochaetes were seen after fifteen minutes. At the centre the parasites were stuck together, but the free extremities were moving actively. In three-quarters of an hour many of the spirochaetes were dead and clumped together, while the number of rosettes was lessened. Along the course of a fair number, one, or sometimes two, of the oval thickenings described above could be seen. Other spirochaetes showed on one side and towards the centre small, rounded, or oval bodies, which appeared to be joined to them by delicate pedicles. After three hours most of the parasites were dead, and appeared more refractile than when alive. After five hours all the rosettes were broken up, and most of the spirochaetes clumped together. Even after ten hours motile spirochaetes were still seen.

In the control, made with normal serum, the spirochaetes acted in the same way as described in the controls mentioned above.

When blood containing spirochaetes was inoculated intraperitoneally in normal rats, the parasites shortly afterwards increased markedly in number, and this multiplication continued until the parasites were found in the peripheral circulation. Granular leucocytes appeared very slowly in the peritoneal fluid, and became numerous only after the lapse of three or four hours. The spirochaetes continued to increase, but the fluid was slowly absorbed until in the course of ten hours none could be withdrawn.

In rats which had passed through the infection the results were somewhat different. In the fluid drawn from the peritoneal cavity 15 minutes after inoculation a distinct increase in the number of parasites was apparent. The leucocytes appeared more rapidly than in the normal rat, and in the course of two hours from 15 to 20 per field were counted. In fresh preparations made two hours after the inoculation very few spirochaetes were seen, most of them deformed, swollen up, and stuck to the leucocytes. After a lapse of from three to four hours no parasites and only a very few leucocytes were seen in the fresh and stained specimens. The stained specimens showed the same appearances.

In rats which had been repeatedly inoculated with infected blood the results were still more different. Living but very sluggish spirochaetes were seen in blood withdrawn two minutes after the inoculation. In the fresh specimen made ten minutes after, no living spirochaetes were seen, while in the stained the parasites were collected together in small clumps. The leucocytes were very scanty and some were filled with broken-up spirochaetes.

The same method of examination was used on rats previously treated with immune and hyperimmune serum, but the phenomena observed were practically the same as those seen in normal rats. Phagocytosis was slightly more pronounced.

1. ACTIVE IMMUNITY

A short preliminary note on the active immunity in experimental animals has been published already from these laboratories.[6]

Many monkeys which had recovered from the disease were reinoculated with the same strain of spirochaetes at varying intervals after the attack.

One *Macacus rhesus* was reinoculated ten days after spirochaetes had been seen last in the blood preparations, and after subinoculation into rats had failed to infect. The monkey received 10 ccm. of heavily-infected blood intraperitoneally, and on the following evening, simultaneously with a rise in temperature, scanty parasites were present in the peripheral circulation (1 in 40-90 fields). On the following morning only one parasite in half a film was found, and no spirochaetes were seen afterwards.

After a lapse of several days it was reinoculated again, but without result.

Another monkey (*Cercocebus fuliginosus*), Experiment 1,015, which had passed through an attack with two relapses was re-inoculated seven weeks after the last relapse. On the third day a rise in the temperature from 102° to 105° F. was noted, but in spite of most careful examination no spirochaetes were found. A rat which was subinoculated at this time did not become infected. Thirty-three days later the monkey was again reinoculated, but not even a rise of temperature followed.

A second monkey of the same species reacted in a similar way.

A *Macacus rhesus*, which had been infected through the bites of ticks and had recovered from an attack followed by one relapse, was reinoculated five weeks later with 8 ccm. of heavily-infected rat blood. A subinoculation, made four weeks after the last relapse, had proved negative. On the second evening after the monkey had been reinoculated two spirochaetes were found in a preparation, but they then disappeared and were never seen afterwards.

Analogous observations were made on a large *Cercopithecus callitrichus*. The reinoculation was followed by a marked rise in temperature to 105·2° F., and although no spirochaetes could be seen in preparations of the peripheral blood, a rat inoculated with 5 ccm. of the monkey's blood, became infected after a prolonged incubation period of seven days.

The experiment given below is of especial interest, in that it suggests the duration of the active immunity.

This monkey (*Cercopithecus sp.?*) was inoculated for the first time on February 22nd, 1906, and the parasites were last seen in the preparations on March 22nd. On July 30th it was reinoculated with 7 ccm. of heavily-infected blood, and on the morning of the fourth day one spirochaete was seen in the blood film, but the parasites had disappeared by evening and were never seen again. On August 2nd a rat was subinoculated with 4 ccm. of nearly pure blood and was infected coincidently with the monkey. This was the only occasion on which parasites were found in the rat's blood.

In rats the results obtained were much the same as in monkeys. A large number of rats were reinoculated at various intervals after recovery from the disease, but in only three cases were the parasites seen in preparations of the peripheral blood, and then, usually, only

within 6-8 hours after the inoculation. Subinoculations, which were made within two or three days of the reinoculation of the rats, were followed by infection in the majority of the cases, but the attacks were always slight in the subinoculated rats.

Active immunity still persisted after a period of seven months, as shown by two rats which were reinoculated with 2·5 ccm. of infected blood each after this time and did not become infected.

The above experiments show that **there is a relatively active immunity against re-infection** as animals reinoculated at various intervals after recovery up to seven and a half months did not become infected at all or only had a very slight attack. Only the first reinoculation of monkeys was followed by a rise of temperature; succeeding ones did not even cause this.

2. TREATMENT

A. Immune Sera

The immune sera used in these experiments were derived from a horse, Experiment 1,019; and from three monkeys and from fifteen rats which had recovered from the disease. The horse serum was obtained seven weeks after the first inoculation.

I. Horse Serum

(*a*) *Preventive*

MONKEYS

Experiment 1,073, monkey (*Macacus rhesus*), weighing 1,538 grm., was inoculated on March 23rd, with 10 ccm. of horse serum. On March 25th and 27th the same amount of serum was given subcutaneously. On the 30th the monkey was inoculated intraperitoneally with 5 ccm. of citrated blood showing 3-5 parasites per field. Although examined carefully twice daily spirochaetes were not found in the blood preparations until seven days later. At first they were very scanty (one to half a film), but increased for the next two days, when 1-5 to a field were seen. Two days later no parasites were found. Only one relapse occurred.

The control monkey of the same species, Experiment 1,074, 1,748 grms., was infected on the third morning (2 to 1 film); the spirochaetes increased in number and were continuously present in the peripheral blood in varying numbers for the next ten days. No relapse occurred.

Experiment 1,104.—*Macacus rhesus*, 2,165 grms., was inoculated on April 6th, 9th, 11th and 14th with 10 ccm. of horse serum on each occasion. Four days later 49 infected ticks were fed on the monkey, but as no parasites had been seen in the peripheral blood, 53 ticks were fed again a week later. The following day a few spirochaetes were found in the preparation (3 to a film), were present for the next five days and then disappeared. A slight relapse of two days' duration occurred five days later. No spirochaetes were found afterwards.

RATS

Experiments 1,112 ((*a*) 160 grm.; (*b*) 145 grm). These rats were inoculated seven times with 7 ccm. of horse serum at intervals of two days. Two days after the last serum injection they were inoculated intraperitoneally with 2 ccm. of citrated blood showing 1-3 spirochaetes per field. In both rats parasites were found in the peripheral blood three days later, and were continuously present for the next eight days. After an interval of 5 days, during which no spirochaetes were found, rat 1,112(*a*) had a relapse lasting one day, while (*b*) had no relapse. The control rat was infected three hours after the inoculation, and spirochaetes were found in the blood for five days, but always in greater number than in the rats treated with the serum. After five days' interval a relapse occurred which lasted for five days.

Other experiments carried out in the same manner with horse serum were followed by similar results.

(*b*) *Curative*

Two monkeys in different stages of the infection were treated with horse serum, but without the slightest effect. The attack continued as in untreated animals, and the relapses occurred as usual. Ten rats, seven mice, and one rabbit treated in the same way showed no difference from the controls.

2. RAT SERUM

(*a*) *Preventive*

MONKEYS

Experiment 1,159, *Cercopithecus mona*, weighing 945 grms., received 15 ccm. of rat immune serum in the course of five days and was inoculated two days later with 2 ccm. of citrated spirochaetal blood. The monkey was infected after an incubation period of 48 hours, passed through an attack of four days' duration, and had one relapse lasting three days.

The control monkey passed through a similar course of the disease.

RATS

All efforts to prevent the disease in rats by means of rat immune serum were unsuccessful. The only result noticed was a slight prolongation of the incubation period, but the rats always became infected, and then passed through the ordinary course of the disease. One experiment only will be quoted in detail, as it presents some remarkable features.

Experiment 1,123, rat weighing 189 grms. It received 9 ccm. of rat immune serum in three doses and was inoculated two days after the last injection with 2 ccm. of citrated heavily-infected blood. Spirochaetes were found in the peripheral blood nine hours afterwards (1 to 30 fields), but disappeared in the course of the next few hours and were not seen again until twelve days later. The rat then had an attack lasting fourteen days, and during part of this time the spirachaetes were very numerous. No relapse followed.

(*b*) *Curative*

Those animals treated with rat immune serum at various stages of the disease displayed no marked difference from the controls. The attacks were not shortened, nor were the relapses prevented.

3. Monkey Serum

The results obtained by the use of monkey immune serum were similar in every respect to those following the use of horse and rat immune serum.

The above experiments lead to the conclusion that immune serum, whether derived from horses, monkeys or rats, has no appreciable value either in preventing the occurrence of the attacks in susceptible animals or in curing the disease once contracted. The incubation period may be prolonged to a greater or less extent, but the inoculation of infective blood is always followed by infection.

B. Hyperimmune Sera

As the use of immune serum conferred no marked passive immunity, serum derived from animals after a varying number of inoculations with spirochaetal blood was employed.

1. Horse Serum

The pony, Experiment 1,019, was reinoculated on April 12th, April 30th, June 7th, July 17th, 19th, 23rd, 26th and 28th with a total of 250 ccm. of heavily-infected blood. The inoculations were partially intravenous and partially intraperitoneal. The pony was bled on the 30th of July and the serum obtained was used in the following experiments.

Unfortunately, large doses of this serum could not be used in rats, as the blood with which the pony was inoculated was derived from these animals. When it was used, haemolysis was set up, and the rats died very quickly from the effects.

(*a*) *Preventive*

Monkeys

A *Macacus rhesus* monkey, weighing 1,513 grms., Experiment 1,290, received in the course of a week 49 ccm. of horse hyperimmune serum. Two days after the last injection sixty infected ticks were fed on it, but as spirochaetes were never found in the peripheral blood, in spite of bi-daily examination, forty more ticks were fed eleven days after the first feeding. Two days afterwards scanty parasites were found in the blood and slowly increased in numbers for the next two days, but never became very plentiful. The monkey had one relapse lasting five days after an interval of one day.

As the incubation period of the infection after tick-feeding is never shorter than five days,[8, 4] the infecting feed, in this case, was the first one. The previous treatment with the hyperimmune serum prolonged the incubation to thirteen days, but the animal then became infected and passed through a mitigated infection.

Experiment 1,345, *Macacus rhesus*, of 1,845 grms. weight. Received 15 ccm. of horse hyperimmune serum in the course of four days, and three days later was inoculated with 4 ccm. of infected blood. The parasites appeared in the blood after an incubation period of seven days, and were present for four and a half days in scanty number (maximum 1 to 40-50 f.). Eight days later a relapse of two days' duration occurred, and was followed after five days by a second relapse lasting three days.

In this experiment the hyperimmune serum had the effect of prolonging the incubation period very markedly and of moderating the severity of the attack.

(*b*) *Curative*

MONKEYS

A large callithrix (*Cercopithecus callitrichus*), Experiment 1,287, weighing 2,200 grms., was inoculated with 5 ccm. of citrated rat blood, showing 1-2 spirochaetes per field. After the usual incubation period the parasites appeared in the peripheral circulation and increased in numbers. On the third day, when there were from 20-25 spirochaetes per field in the blood film, the monkey was injected subcutaneously with 9 ccm. of the horse serum, but without result. The spirochaetes continued to increase and on the second day after the serum was administered were innumerable. On the third day the monkey died from the disease.

Another monkey (*Macacus rhesus*), Experiment 1,326, weighing 1,370 grms., was inoculated with 3 ccm. of citrated infected blood from a rat (mixture showed 1 parasite to a field). On the third day when there were 1-2 parasites per field in the preparation, it received subcutaneously 15 ccm. of horse serum, but, nevertheless, the number of the spirochaetes increased. Two hours later from 2-4 per field were seen; on the following day 6-20 per field, and on the next day 5-7 per field. On the following day no spirochaetes were seen in the peripheral blood. A relapse occurred after an interval of three days.

These two experiments demonstrate that **horse hyperimmune serum is of no pronounced value in the treatment of the disease in monkeys.** The one monkey died from the disease, while the other passed through an attack almost identical with that observed in the controls.

RATS

It was scarcely possible to make valid experiments to judge of the efficacy of the hyperimmune horse serum in preventing the occurrence of the disease in rats, as small doses had no effect and larger ones

caused the death of the animals through haemolysis. An attempt was made, however. The serum was used in the treatment of the disease in rats.

A series of four were injected subcutaneously with 0·5, 1, 1·5 and 2 ccm. respectively, on the day after they had been inoculated with infected blood. The rat which received 2 ccm. died four days later with all the signs of haemolysis, and with very many spirochaetes in its blood. The other three became infected at the same time as the control and passed through an attack followed by relapses in the ordinary manner.

In another experiment three rats were inoculated simultaneously with hyper-immune serum and infected blood in the proportions of 3:1, 1:1, and 1:2. In each case the dose used was 1 ccm. The first rat was infected on the sixth, the second on the fifth, and the third on the third day. The control rat was infected on the day after inoculation. The treated rats then passed through a slight attack followed by one relapse. The number of the parasites was always small (maximum 2-3 per field) as compared with the control (60-80 per f.).

2. Monkey Serum

Serum from three hyperimmunised monkeys was also used in efforts to prevent and cure the disease.

The monkeys were allowed to pass through an attack and after they had recovered, *i.e.*, in about four weeks, were reinoculated with large doses of infected blood. Two weeks later they were again reinoculated, and after another week received from five to seven injections of infected blood at intervals of two days. In the course of this treatment large amounts of blood containing numerous spiro-chaetes were used, up to 80 ccm. in one case. The animals were then bled and the serum obtained.

(*a*) *Preventive*

Rats

A rat weighing 84 grms. which had received subcutaneously 4·7 ccm. of serum was inoculated the next day with spirochaetal blood, and became infected on the fourth day afterwards. The control was infected on the day following inoculation. The course of the disease ran a similar course in both rats but the spirochaetes were never as numerous in the serum animal as in the control.

In another experiment, five rats received injections of 2, 3, 4, 5 and 6 ccm. of the serum respectively, and were inoculated after an interval of two days with infected blood. They were all infected on the third day, and then passed through the ordinary course of the disease. Spirochaetes were found in the peripheral blood of the control rat on the day after inoculation, and were always present in greater numbers than in the serum rats.

In another series, three rats were inoculated respectively with 1 ccm. of mixtures of monkey hyperimmune serum and spirochaetal blood in the proportions of 3 : 2, 2 : 3, and 3 : 1. The only noticeable feature in this experiment was that these rats did not become infected until the third day afterwards, while the control was infected on the following day. The severity of the attack differed in the three rats. In the one receiving the serum and blood in the proportion of 3 : 1 the attack and relapse were very slight, and the parasites were always scanty. In the other two the infection was more typical, but the number of spirochaetes was always smaller than in the case of the control.

(*b*) *Curative*

MONKEYS

A monkey (*Cercopithecus callitrichus*), Experiment 1,299, weighing 1,950 grms., was inoculated with a small dose of heavily-infected rat blood, and on the third day of the disease, when there were two or three spirochaetes per field in the blood films, received subcutaneously 5·5 ccm. of monkey hyperimmune serum. Four hours later the parasites had disappeared from the peripheral blood, but reappeared after thirty-six hours. The monkey then had the usual attack, and on the fifth day, when the blood preparations showed 1-2 spirochaetes in a field, received a further injection of 5 ccm. of the serum. Spirochaetes were seen in the preparation made on the same evening, but were very scanty (2 to ½ film). None were found for the next seven days, but on the eighth day the spirochaetes were again present in the peripheral circulation, and the monkey then had a relapse lasting five days.

RATS.

Five rats which had been inoculated with blood containing numerous spirochaetes were treated on the second day of the disease when showing many parasites, with monkey hyperimmune serum (0·5, 1, 2, 3 and 5·5 ccm. respectively). There was no effect. The parasites increased rapidly as in the control and the rats passed through typical attacks and relapses.

3. RAT SERUM

The hyperimmune serum was obtained from twenty-five rats which had recovered from the disease and were then inoculated interperitoneally at intervals which shortened from two weeks to every second day. Some rats received as many as sixteen doses of from 2·5-4 ccm. of heavily-infected blood. The rats stood the many inoculations perfectly.

(*a*) *Preventive*

MONKEYS

No preventive experiments were made on monkeys.

RATS

Three rats were inoculated respectively with 3, 4 and 5 ccm. of the serum, and on the following day with 3 ccm. of heavily-infected blood. All of them became infected after prolonged incubation periods (3, 3 and 5 days), and passed through a slight infection.

(*b*) *Curative*

MONKEYS

A small *Cercopithecus callitrichus*, Experiment 1,319, weighing 1,215 grms., was inoculated with spirochaetal blood and became infected as usual. On the third day there were 10-15 parasites per field in preparations of the peripheral blood, and the monkey then received 10 ccm. of rat hyperimmune serum subcutaneously. Four hours later the number of spirochaetes was the same as before the injection of serum, but in six hours had diminished to 6-8 per field, and by the following evening only one to two hundred fields was seen. The monkey had no relapse. Six weeks later the monkey was reinoculated with 7 ccm. of heavily-infected blood and spirochaetes were found in the peripheral blood on the following morning. This attack lasted three days.

RATS

Seven rats, weighing from 120-150 grms. were treated at different stages of the initial attack with hyperimmune serum. The serum was administered subcutaneously in doses of from 1-3 ccm. In every case the results were very discouraging. In only one rat the number of parasites did not reach the same level as in the control.

The above experiments show that hyperimmune serum, whether derived from horses, monkeys or rats, does not prevent the infection, although it lengthens the incubation period very markedly when given in sufficiently large doses, and mitigates the course of the disease to a marked extent. No cure has been effected by the use of this serum; in some cases the disappearance of the spirochaetes was hastened, but they reappeared in the course of a few days. The relapses were prevented only in one case, Experiment 1,319, but occurred in all the others.

Animals which have been treated with immune and hyperimmune sera and have then been inoculated with spirochaetal blood and have recovered from the resulting infection, usually exhibit no greater degree of active immunity than do those animals which have recovered from the disease but have not been treated with immune sera. In the one case in which we were able to cut short the attack and prevent the occurrence of relapses the immunity was not very pronounced, and corresponded in degree to the immunity observed in animals which had originally only a slight attack.

3. INBORN IMMUNITY

As spirochaetes were present in the fœtuses of infected rats, the question as to whether the young, born from such mothers, possessed any immunity against the disease naturally suggested itself. Experiments to throw light on this question were made.

Two rats, three weeks old, from a mother which had littered just after an attack lasting eleven days, were inoculated with 0·5 ccm. of infected blood. A control of the same age was used. The rats were infected on the following day and had an attack of three days' duration after which the spirochaetes disappeared from the peripheral blood and were never seen again. The control had a typical attack with one relapse.

Two of the same litter were inoculated when six weeks old with 0·5 ccm. of spirochaetal blood and had attacks lasting seven days, but no relapses were observed. The control rat of the same age passed through the ordinary course of the disease with one relapse.

Another young rat of another litter, two months old, borne by a heavily-infected mother in the first attack, was inoculated and passed through an attack identical with that of the control.

Infected ticks were fed on two rats nine weeks old, born while the mothers were heavily-infected in the first attack, but they became infected as readily and passed through as typical attacks as did normal rats of the same age.

These experiments show that **there is a slight degree of inborn immunity which disappears in a very short time.**

The results of all the work on immunity may be summed up in the following conclusions:—

(1) **In animals which have recovered from the infection there is a relatively active immunity of comparatively long duration.**

(2) **We have been unable to produce passive immunity through the use of immune serum.**

(3) **Serum from hyperimmunised animals, whether horses, monkeys or rats, does not protect a susceptible animal against the disease, but does prolong the incubation period and mitigates the severity of the infection.**

(4) **Immune serum has no curative action whatever; hyperimmune serum occasionally cuts short an attack but does not prevent the occurrence of relapses.**

(5) **There is a slight inborn immunity of short duration.**

IX. The Specific Nature of Sp. duttoni

The question of the active immunity observed after infection by *Spirochaeta duttoni*, and also after infection by *Spirochaeta obermeieri*, has been discussed elsewhere in this report. As no morphological peculiarities sufficient for exact differentiation existed, the only method by which the specific nature of the spirochaete of the African tick-fever could be demonstrated was by inoculating animals which have recovered from that disease with the spirochaete which caused European relapsing fever, and *vice versâ*. With this end in view, many experiments have been made, and the results of these show conclusively that the spirochaete of the African tick-fever is a distinct species.

A *Macacus rhesus* was inoculated on March 22nd, with *Spirochaeta obermeieri*, and after recovering from the disease was reinoculated with the same strain. No parasites were seen after this inoculation, but a subinoculated rat had a slight attack. Ten days later the monkey was inoculated with the African strain, and became infected on the following day. The attack lasted five days and was followed by one relapse. The disease was of the ordinary type observed in monkeys suffering from a first attack of African tick fever.

Another *Macacus rhesus* which was inoculated with *Sp. obermeieri* had an attack of four days' duration followed, after an interval of four days, by a relapse lasting five days. When it had recovered from the disease subinoculations were

made, but the rats did not become infected. The monkey was then reinoculated with the African strain, became infected after an incubation period of one and a half days, and then passed through the typical course of the disease seen in monkeys inoculated with that strain. The attack was followed by two relapses, the last of which was of two days' duration.

The same results were obtained in rats when the strains were crossed.

In the blood preparations of a rat inoculated with *Spirochaeta obermeieri*, which had been kept in defibrinated blood for twelve days, no spirochaetes could be seen, most probably on account of insufficient observations. At intervals of four and seven weeks after the original inoculation this rat was reinoculated, but spirochaetes were never seen in the peripheral blood, although it was very carefully examined. Eight days after the last reinoculation, it was inoculated with the African strain and became infected after a period of nine hours. The attack was of the usual type and was followed by two relapses.

Another rat which was inoculated with *Sp. obermeieri* had an attack lasting three days, and one relapse. Five weeks later it was reinoculated with the same strain, but the parasites were never seen in the preparations. When inoculated, seven days later, with the African strain the rat passed through a course of infection similar to that of the control.

In another case two rats which had recovered from the infection with *Spirochaeta obermeieri* were reinoculated four and five times respectively with the same strain. No parasites were found after these inoculations. The rats were inoculated with the African strain three days after they had received the last injection of *Sp. obermeieri*. The parasites appeared in the peripheral circulation after the ordinary incubation period, 24 hours, and the two rats then had a severe attack.

When animals were inoculated, first with the African strain and then with the *Spirochaeta obeimeieri* the same results were obtained.

One monkey, Experiment 1,227, after inoculation with the African strain, had a typical attack with one relapse, and was reinoculated without result two weeks after the parasites had been seen last in the blood. Six weeks later it was inoculated with *Sp. obermeieri* and had an attack of four days' duration. Similar observations were made in the case of rats.

Two rats which had recovered from infection with *Sp. duttoni* were reinoculated four and a half weeks later with the same strain but did not become infected. Four and a half weeks afterwards they were inoculated with *Sp. obermeieri* and then became infected in the same manner as the controls.

Two other rats were treated in the same way and with exactly the same results.

From the above it will be apparent that **the spirochaete of the African tick-fever is of a species differing from *Spirochaeta obermeieri*, since each confers a relatively active immunity against itself, but not against the other.** Therefore, for the spirochaete of the African tick-fever the name *Spirochaeta duttoni* was suggested.[6]

X. Passage of Spirochaetes through the Placenta

In a publication on *Spirochaeta obermeieri*, Albrecht states that he found the parasites in three fœtuses, seven months old, from

mothers who were suffering from European relapsing fever.[1] Spitz made a similar observation in the case of a five-months' fœtus, finding the parasites in an intracranial haemorrhage.[32]

During the course of our experimental work on *Spirochaeta duttoni*, we have been able to demonstrate the passage of the parasites from mother to fœtus in the case of four rats and one guinea-pig.[5]

Experiment 1,082C.—This rat was inoculated on April 3rd with heavily-infected blood, and after it had shown parasites for sixteen consecutive days, it was killed for subinoculation. In preparations of the heart blood from 20-30 spirochaetes per field were seen. Three half-grown fœtuses were found in the rat, and the heart blood of these together with that of the placentas was examined with the following results:—

Placenta I.—1-2 spirochaetes per field:	Fœtus I.—1 spirochaete to film.
,, II.—6-8 ,, ,,	,, II.—4 ,, ,,
,, III.—1-3 ,, ,,	,, III.—1 ,, ,,

Film preparations of the brain, bone marrow and spleen of one fœtus were examined; parasites were found only in the preparations from the spleen.

Experiment 1,084.—Rat, inoculated on April 6th. Three days later, when the blood contained innumerable parasites, it was killed. The fœtuses (seven) were nearly mature. The placentas were darker in colour than usual, but otherwise presented no macroscopical changes. In blood from the uterine vein, the spirochaetes were present in very large numbers, and in the placental blood they were in such numbers that in the preparations nothing but large bundles of spirochaetes could be seen. In preparations from the umbilical vein, one spirochaete was seen in from 5-30 fields. The preparations of the fœtal heart blood showed varying numbers, on an average one to three fields, though in some fields as many as ten spirochaetes could be counted.

Experiment 1,178C.—Rat inoculated on May 26th and killed three days later when the heart blood showed from 70-100 parasites in a field. The seven fœtuses were nearly mature. The blood in the uterine vein showed about the same number of parasites as the heart blood. The results of the examination of the fœtal blood is tabulated below.

	Placenta	Umbilical Vein	Fœtus
I.	80–100 per field	1–5, 1–9, 1–30 fields	Negative
II.	30–40 ,,	—	,,
III.	10–40 ,,	1–2, 1–4, 1–48 fields	1 in film
IV.	3–30 ,,	2–1, 1–6 ,,	1 ,,
V.	30–100 ,,	1–7, 1–78, 1–90 ,,	2 ,,
VI.	30–100 ,,	—	2 ,,
VII.	10–70 ,,	1–57, 1–70, 1–100 fields	3 ,,

Subinoculations were made from rat 1,178C and the fœtuses to ascertain whether the spirochaetes in the fœtal circulation were still infective and as virulent as those in the maternal blood.

Experiment 1,182.—Two rats were inoculated from the mother. Both showed many parasites in the peripheral circulation after an incubation period of four hours, and passed through the usual course of the infection. Another rat

inoculated with three cubic centimetres of citrated heart blood from three of the fœtuses showed two spirochaetes in a preparation of the peripheral blood after an incubation period of six hours. No parasites were seen for the next two days, but on the fourth day they were again present, and the rat then passed through the ordinary course of the disease.

Experiment 1,238.—This rat was inoculated on July 3rd, and was killed three days later. From one to two spirochaetes per field were seen in preparations made from the heart blood. In the blood of eight of the ten half-grown fœtuses, parasites were seen in very scanty numbers (never more than two to a thick film). In the placental blood there were, on an average, from one to two spirochaetes per field.

Experiment 1,152.—Pregnant guinea-pig. It was inoculated on May 13th, and became infected after an incubation period of six hours. It died on May 18th, and although no spirochaetes were seen in the blood preparations made after death, a subinoculated rat was infected on the following day. The fœtuses were about three-quarters mature. Although preparations of their blood were examined carefully no parasites were found, but the inoculation of a rat proved positive after a prolonged incubation period of six days, and the infection ran its usual course.

The above experiments lead to the following conclusions:—

I. *Spirochaeta duttoni* passes through the placenta from the circulation of the mother to that of the fœtus.

II. The majority of the fœtuses carried by an infected mother are themselves infected.

III. The parasites are found in the placenta in approximately the same numbers as in the maternal heart blood, but on the contrary, occur in very scanty numbers in the fœtal circulation.

IV. (*a*) From our observations we can add, the spirochaetes in the fœtal circulation show no morphological changes.

(*b*) Infected pregnant rats show no tendency towards abortion, but few of their young, in comparison with those from healthy mothers, reach maturity.

XI. Rôle of the Spleen in Spirochaetal Infection

The rôle of the spleen in spirochaetal infections has always been a question of great interest. Metchnikoff,[16] in 1887, found that spirochaetes were present in the peripheral blood of a monkey 59 hours after it had been inoculated, but that none were present in the spleen. A piece of the spleen was removed by means of the thermocautery from another monkey, when the peripheral blood was filled with spirochaetes, but the examination revealed the presence of only a very few parasites, some free and others engulfed in leucocytes. In another case, when the temperature had reached 41° C. and the

spirochaetes had disappeared completely from the peripheral blood, the spleen was taken out and was found to be filled with parasites, part of them free, part engulfed in spleen cells. The inoculation of a piece of this spleen in another monkey was followed by infection. It was thought at this time that the peripheral blood was non-infective during the interval between attack and relapse. Soudakewitch[31] experimented on two monkeys, which he splenectomised. The first died on the eighth day of the infection with very numerous spirochaetes in the peripheral blood and in that from the Inferior Vena Cava. At the autopsy it was found that a small accessory spleen had been overlooked. The second monkey died on the ninth day of the disease, also very heavily infected. From these experiments, Soudakewitch concluded that the spleen is the only organ in which the spirochaetes are destroyed, and that spleenless animals cannot recover from the infection. Tictin[35] splenectomised a monkey, and then inoculated spirochaetal blood. On the seventh day of the disease it died from tuberculosis, and parasites were present only in the blood. No phagocytosis was observed in the lymph glands or bone marrow. A second splenectomised monkey did not become infected when inoculated, probably because it was immune. A third was splenectomised after the attack, but severe relapses occurred and the monkey finally recovered. The inoculation of a fourth splenectomised monkey with spirochaetal blood was followed by a rather severe infection and recovery.

Lamb[13] splenectomised five monkeys after they had recovered from the first attack and then reinoculated them, in only one case with a resulting infection. Two uninfected monkeys were inoculated with spirochaetal blood after the spleen had been removed, and both recovered from the disease which followed.

In order to determine the rôle of the spleen in spirochaetal infection, a large number of animals were splenectomised at different stages of the disease. The strictest asepsis was observed in the operations. After the animal was anæsthetised, a longitudinal incision, starting just below the costal margin, 2·5 to 5 cm. long in monkeys and 1·5 to 2 cm. in rats, was made, and the peritoneum opened. As a rule, the spleen could be brought out at once and tied off. When a little experience had been gained, it was possible to do this through a very small opening without introducing the fingers into

the peritoneal cavity. The wound was closed by suturing the various tissues separately, and dressed with a cotton and collodion dressing covered over with a layer of thick celloidin. By pouring a few drops of chloroform over the celloidin, it became hard at once and then protected the wound very efficiently. We found the combination of collodion and celloidin much more effective than either alone. The flexible collodion kept the skin from wrinkling up while the hard casing of celloidin prevented the animals from picking off the dressing.

The results obtained were most gratifying, as in every case the wound closed by first intention. All the animals used bore the anæsthetic very well, and usually recovered completely from its effects within a very short time.

The animals stood the operation well, and no after results were noticed. The only change observed in the blood was an absolute, as well as relative, increase in the number of lymphocytes. The animals lived for a comparatively long period afterwards.

The experiments may be divided into the following groups:—

I. Splenectomy, and subsequent inoculation.
II. Inoculation, and splenectomy during the first interval.
III. Tick feeding, and splenectomy during the incubation period.
IV. Splenectomy after recovery, reinoculation.

1. Splenectomy of Normal Animals followed by Inoculation

Experiment 1,147.—This monkey (*Macacus rhesus*) was splenectomised on April 30th and after it had recovered completely was inoculated on the 10th of May with 5 ccm. of infected blood. Two hours later spirochaetes were present in the peripheral circulation and increased in number until the death of the monkey, which occurred on the third day after inoculation. The monkey's death was accelerated by a bad attack of diarrhœa which was present at the time of inoculation.

The temperature did not rise above 103° F. during the whole course of the disease and on the evening before the animal died fell to 98·6° F., and remained subnormal until death.

Post mortem the thoracic viscera did not show any changes. The liver was markedly enlarged and showed subcapsular haemorrhages of varying extent. The bone marrow was very soft, congested and of a dark purple colour. Throughout its substance small, whitish areas were seen. The inguinal and axillary lymph glands showed haemorrhagic infiltration. The gut was deeply infected and the mesenteric lymph glands were enlarged, but of normal colour. Films were made of all the organs and of blood taken from various sources and stained by Giemsa's method. In the films of the heart and peripheral blood very numerous free spirochaetes were seen, but only a very few inside the leucocytes. The number of parasites in the blood from various sources, *e.g.*, heart, inferior vena cava, renal vessels, &c., did not differ.

Experiment 1,205.—*Macacus rhesus*, weighing 1,723 grms. It was splenectomised on May 22nd and inoculated on June 11th with 5 ccm. of infected blood. Spirochaetes were found in the preparations seven hours later. They increased in number for the next three days, on the fourth day only a very few parasites were found and none on the following day. Films were made from the blood when the spirochaetes were diminishing in number, and examined for phagocytosis but very little was found. A relapse occurred seven days later and lasted five days. No spirochaetes were seen after this. A month after the relapse the monkey was reinoculated, and while it did not become infected, a rat subinoculated from it became infected and passed through a slight attack.

The course of the disease in the control was similar to that outlined above.

Four rats were splenectomised and afterwards inoculated. In two of these the disease was of the usual type. They became infected as promptly as the controls and had an attack followed by two relapses. After the attacks the spirochaetes disappeared from the peripheral circulation as in normal rats, to reappear at the time of the relapses. Spirochaetes were present in the peripheral circulation of the other two rats on the day after the inoculation, but had disappeared by the succeeding day. After an interval of three days they reappeared and were continuously present in the peripheral blood for eleven days in both cases. One rat then remained negative but the other had a second relapse of short duration. The control passed through the usual course of the infection.

These experiments show that **the course of the disease in spleenless animals does not differ in any way from that noted in normal animals; the spirochaetes appear in the peripheral circulation, increase in numbers to the maximum, then decrease until finally they are absent from the blood and after an interval repeat the same cycle in the ordinary manner.** The death of the first monkey was due not to the absence of the spleen but largely to the severe attack of diarrhœa.

One puppy, two rabbits and two guinea-pigs were also splenectomised and afterwards inoculated with spirochaetal blood, and they reacted in the same way as normal animals.

2. Inoculation followed by Splenectomy after the first Attack

In order to observe whether the spirochaetes rest solely in the spleen during the intervals, animals were splenectomised immediately after recovering from the first attack, and were watched carefully for the appearance of relapses.

Experiment 1,206.—*Macacus rhesus*, weighing 2,280 grms. This monkey was inoculated and had an attack of five days' duration. Four days after the spirochaetes had disappeared from the peripheral circulation the spleen was removed. A relapse occurred eighteen days later or twenty-three days after the end of the original attack, whereas the control monkey had the relapse ten days after the attack.

At the time of the operation the spleen was ground up in salt solution and injected into two rats (4 ccm. each) and a third was subinoculated from the blood. One of the rats which were inoculated with the spleen *became infected seven days*

later, at the same time as the one which had been inoculated with the blood. It passed through a slight attack followed by a relapse. The other did not become infected.

Films made from the monkey's spleen did not show anything remarkable. Spirochaetes were not seen in the five films examined.

Two rats, Experiment 1,198, which had recovered from an attack were splenectomised, and in both of them the relapse occurred at the same time as in the control. The spirochaetes became numerous in the peripheral circulation and then disappeared finally.

Inoculations into two rats were made with the ground-up spleen from one of the rats, Experiment No. 1,198, when operated on. Another rat was inoculated at the same time with blood from the same rat. In this case all the rats became infected and the two which had received the spleen passed through prolonged attacks lasting seven and nine days respectively. No relapses occurred.

These experiments tend to show that the spirochaetes when disappearing from the blood do not rest solely in the spleen. From the fact that rats which were inoculated from the blood during the intervals, and from the ground-up spleen, became infected, we must conclude that the spirochaetes are present in an infective stage in both. Of course, spirochaetes as such may be present during the interval between the attack and relapses, but if so they must be very scanty, since an examination of numerous thick films of the peripheral blood during this period has always proven negative.

3. Tick Feeding and Splenectomy during the Incubation Period

After ticks have been fed on a susceptible animal the spirochaetes are not present in a sufficiently great number to be seen in preparations of the peripheral circulation until after a period of five days has elapsed.[4, 8] In order to solve the question whether the multiplication of the parasites during this incubation period occurs only in the spleen which, of all the organs, is the one most markedly changed, or proceeds in the peripheral circulation as well, we fed infected ticks on a monkey and removed the spleen a few days later. In addition, a rat was subinoculated from the monkey each day during the period of incubation.

Experiment 1,175, Chart X, *Macacus rhesus*, of 2,253 grms. weight. On May 25th, 108 infected ticks were fed and three days later the monkey was splenectomised. On the seventh day after the ticks had been fed the monkey became infected and had an attack lasting seven days. A relapse of four days' duration occurred six days after the attack. Spirochaetes were never seen afterwards.

The rat which was subinoculated on the day following the tick feeding (4 ccm. of citrated blood) became infected on the eleventh day and had a slight attack which lasted two days. No relapse occurred.

The rat subinoculated on the second day (3 ccm. of citrated blood) was infected on the ninth day and the attack lasted seven days. The parasites were present in fair numbers in the peripheral blood.

DISEASE

Notes of Case.

Name MONKEY EXP. 1175

Age

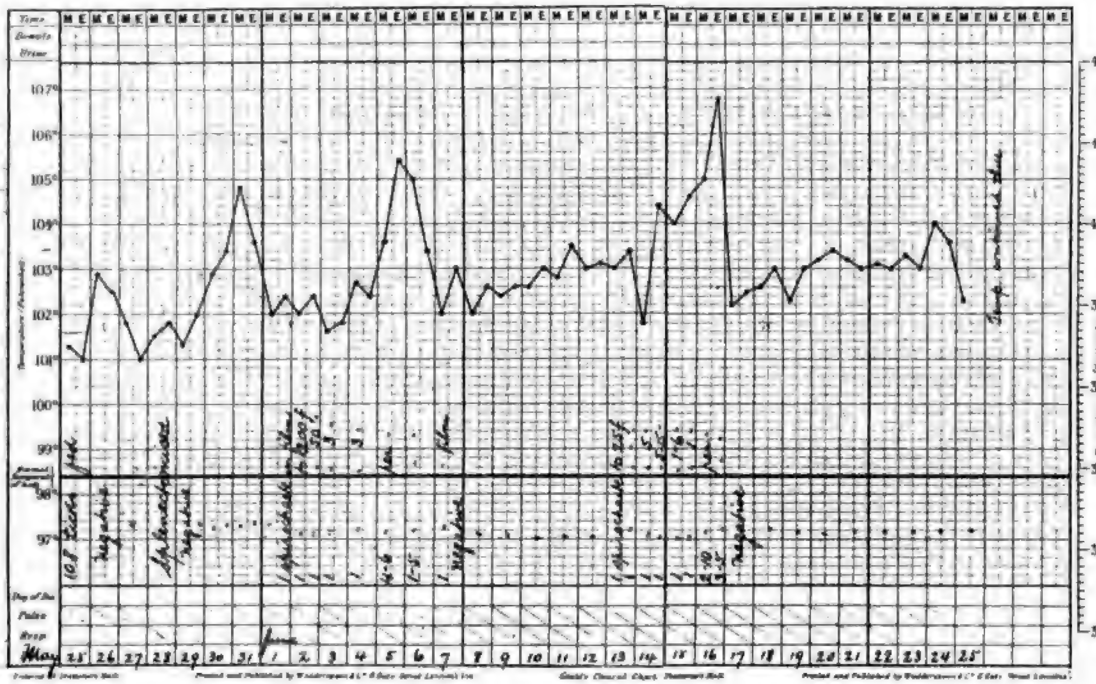
Dur.

Case Book No.

Chart 10

Date of admission

Result



After an incubation period of seven days the rat inoculated on the third day after ticks were fed (3 ccm. of citrated blood) became infected and had an attack lasting nine days, during which the spirochaetes were found in a fair number in the blood preparations. At the same time two rats were inoculated with the monkey's spleen which was first ground up in normal salt solution. Both these rats became infected after an incubation period of twelve days, and passed through slight attacks of two and three days' duration respectively. The spirochaetes were present in small numbers. Only one of the rats had a relapse.

The rat subinoculated from the monkey on the fourth day after the ticks were fed became infected after an incubation period of four days, and had an attack lasting ten days, with one relapse.

The rat inoculated on the fifth day was infected three days later, and had an attack lasting two days, followed by two relapses.

Spirochaetes were found in the peripheral blood of the rat subinoculated on the sixth day, after an incubation period of one day. The attack lasted two days and the rat had no relapses.

Day after Feeding	Incubation Period	Duration	Relapse
1st Day ...	10 Days ...	2 Days ...	—
2nd „ ...	8 „ ...	7 „ ...	—
3rd „ ...	7 „ ...	9 „ ...	1 Relapse
4th „ ...	4 „ ...	10 „ ...	1 „
5th „ ...	3 „ ...	2 „ ...	2 Relapses
6th „ ...	1 „ ...	2 „ ...	2 „
Spleen Juice Rat A ...	12 „ ...	2 „ ...	—
„ „ „ B ...	12 „ ...	3 „ ...	1 Relapse

This experiment shows that **spirochaetes are present in the peripheral circulation in an infective stage on the first day after ticks are fed on a susceptible animal.** As will be seen from the table given above, the incubation period in the subinoculated rats became shorter, the nearer we drew to the day on which spirochaetes appeared in the peripheral circulation of the monkey, while the severity of the attack increased. From the fact that the two rats inoculated with the spleen pulp became infected five days after the rat inoculated at the same time with blood, it will be evident that the rôle played by the spleen during the onset of the disease is very slight.

As a confirmatory experiment, a white rat was splenectomised on the third day after forty ticks had been fed. At the time of operation a rat was inoculated with blood from this animal and two others were inoculated with the spleen pulp. On the sixth day after the ticks were fed the rat became infected and had an attack of four days' duration. After a negative interval of one day the spirochaetes reappeared and increased in number until the rat died in ten days. Of the rats inoculated at the time of operation, the one injected with blood became infected in four days and only one of the two inoculated with the spleen pulp, after an incubation period of five days. Both the attacks were very slight and lasted one and three days respectively with no relapses.

4. Splenectomy after Recovery from the Disease followed by Reinoculation

In order to determine whether the presence of the spleen has any bearing on the active immunity, a monkey and two rats which had completely recovered from the disease were splenectomised. These animals, however, reacted in the same manner to reinoculation as the controls.

(1) In splenectomised animals, the spirochaetes disappear from peripheral circulation after the attack as promptly as in normal animals and relapses occur in the ordinary way.

(2) When the spleen is removed shortly after the spirochaetes have disappeared from the peripheral circulation after the first attack, the relapses occur as in the controls.

(3) During the incubation period, after ticks have been fed on a susceptible animal, the spirochaetes do not develop in the spleen as the site of election.

(4) Active immunity against reinfection is not influenced by the spleen.

XII. Filtration Experiments

Novy and Knapp were the first to demonstrate that spirochaetes are able to pass through a Berkefeld filter.[24] We have repeated the experiments with *Spirochaeta duttoni*, and the importance of the fact necessitates a detailed description. Berkefeld filter cylinders No. 9 were employed. The blood for filtration was diluted in the proportions of 1 : 10 and 1 : 20, with a 2·5 % solution of sodium citrate in physiological saline. The filtration was carried out in from thirty to sixty minutes, and only the vacuum process was employed. The manometer during the filtration registered 65 cm. of mercury. As control a laboratory culture of *Bacillus prodigiosus* was used, and subcultures were usually made with 2 ccm. of the filtrate on agar and potatoes, and kept in the incubator at 22° C. At the commencement the blood passed through the filter very quickly, but later the process became much slower, until finally the fluid passed through only in drops. The filtrate was of a ruby colour, and microscopically did not contain any foreign particles. The filtrate was always injected intraperitoneally in rats. The blood used for filtration was obtained from rats at various stages of the disease:—

(*a*) When the parasites were increasing in number.
(*b*) When the parasites started to decrease in number.
(*c*) When the peripheral blood contained no spirochaetes.

The chief points in the following experiments are tabulated below.

Experiment 1,312.—Blood was taken from a rat in which the parasites had just disappeared from the peripheral circulation and was diluted in the proportion of 1 : 10. The filtration lasted an hour. Six ccm. of the filtrate was inoculated in a rat. The subcultures remained sterile. Although examined carefully for the next sixteen days no spirochaetes were found in preparations of the peripheral blood. The rat was then inoculated with spirochaetal blood and passed through an attack identical with that of the control.

Experiment 1,328.—The blood used for filtration was derived from a rat which had numerous parasites in the peripheral circulation on the second day of the attack. It was diluted in the proportion of 1 : 20, and filtered during a period of thirty minutes. Two rats were inoculated, one with 7 ccm. and the other with 5 ccm. of the filtrate. The subcultures did not show any growth of *B. prodigiosus*. The first rat became infected after a period of seven days, and in the preparations only one spirochaete to a film was found. The parasites were never seen again. The other rat remained negative throughout. Both were reinoculated afterwards with spirochaetal blood, were infected at the same time as the control, and passed through a typical infection.

Experiment 1,329.—The blood in this case was also from a rat in the second day of the infection, when numerous spirochaetes were present. The dilution was 1 : 10 and the filtration lasted thirty minutes. The subcultures remained sterile. Three rats were inoculated. (*a*) with 7, (*b*) with 4, and (*c*) with 3 ccm. of the filtrate. (*b*) remained negative. (*a*) became infected on the third day, the spirochaetes on an average were 1 to 10 fields. Two days later this rat had a relapse lasting three days, during which the spirochaetes were always scanty, never more than one to five fields. Rat (*c*) was also infected on the third day in the same way as (*a*), and had a relapse three days afterwards of three days' duration.

Experiment 1,332.—The rat from which the blood was obtained for filtration was in the sixth day of the disease when the parasites had first started to decrease in numbers. A dilution of 1 : 20 was used and the blood filtered during forty-five minutes. Subcultures of the filtrate remained negative. Two rats were inoculated, one with 7 the other with 5 ccm. of the filtrate. Neither rat became infected. They were inoculated with infected blood after eleven days and showed spirochaetes the following day.

Experiment 1,333.—Blood from a rat in the same stage of the disease as the above was filtered. Dilution 1 : 10; time of filtration forty-five minutes. Subcultures remained negative. Two rats were inoculated, one with 7 and the other with 4 ccm. of the filtrate, and both were infected after an interval of two days. The parasites were found in very scanty numbers on one day only.

Experiment 1,340.—The rat was entering on a relapse on the seventh day after inoculation and only one spirochaete in from 1 to 40 fields was seen. The blood was diluted in the proportions 1 : 10 and filtered in thirty-five minutes. Subcultures remained negative. Two rats were inoculated with 7 and 2 ccm. of the filtrate, but did not become infected. When reinoculated later with spirochaetal blood they became infected promptly.

Experiment 1,341.—Blood was taken from a rat in the same stage of the disease as in 1,340. The dilution was 1 : 20 and time of filtration thirty-five minutes. Subcultures remained negative. Two rats were inoculated with 8 and 4·5 ccm. of the filtrate, but did not become infected. They became infected, however, when inoculated with blood containing spirochaetes.

Experiment 1,346.—The blood was from a rat which had one spirochaete in a field in preparations of the peripheral blood. On the previous day numerous spirochaetes had been found. It was diluted in the proportion of 1 : 20 and filtered for twenty minutes. Subcultures were negative.

Two rats were inoculated, (*a*) with 15, (*b*) with 7 ccm. of the filtrate. (*a*) became infected after an incubation period of three days, and in the peripheral blood the spirochaetes were present only in very scanty numbers, 1 to 150 fields. Two days later the blood became negative and remained so. Rat (*b*) never became infected.

Experiment 1,347.—Blood was obtained from a rat in the same stage of the disease as rat 1,346. Dilution 1 : 10; time of filtration, forty minutes. *The subcultures shewed colonies of B. prodigiosus on the second day.* Both rats which had been inoculated with the filtrate were infected on the second day afterwards, and passed through severe attacks during which numerous spirochaetes were found in the preparations. Nothing can be said from this experiment as a leak probably existed in the filter which allowed the bacilli to pass through.

Experiment Number	Stage of Disease	Dilution	Duration of Filtration	Amount of Filtrate Injected	Result of Inoculation	Subcultures
1,312	Interval	1 : 10	60 minutes	6 ccm.	—	Negative
1,328	Height of Attack	1 : 20	30 "	A 7 "	+ After 7 days	"
				B 5 "	—	
1,329	" "	1 : 10	30 "	A 7 "	+ After 2 days, 1 relapse	"
				B 4 "	—	
				C 3 "	+ After 2 days, 1 relapse	
1,332	Decline	1 : 20	45 "	A 7 "	—	"
				B 5 "	—	
1,333	"	1 : 10	45 "	A 7 "	+ After 2 days	"
				B 4 "	+ " "	
1,340	Onset of Relapse	1 : 10	35 "	A 7 "	—	"
				B 2 "	—	
1,341	" "	1 : 20	35 "	A 8 "	—	"
				B 4·5 "	—	
1,346	Decline	1 : 20	20 "	A 15 "	+ After 3 days	"
				B 7 "	+ " 5 "	
1,347	"	1 : 10	40 "	A 7 "	+ After 2 days	Positive on 2nd day
				B 4 "	+ " "	

The above experiments show that **an infective stage of *Spirochaeta duttoni* is capable of passing through a Berkefeld filter, which does not allow the passage of Bacillus prodigiosus.**

XIII. The Morphology of Sp. duttoni

The studies on the morphology of *Spirochaeta duttoni* are not yet completed, so that no definite conclusions on this head can be drawn at present.

FRESH SPECIMENS

The spirochaetes possess from six to ten spiral turns, and are very actively motile. The movement can be analysed into a rotary movement round an imaginary longitudinal axis, a movement of the individual spirals, lateral movement of the spirochaete and progressive and retrogressive movement. As the parasite passes between the blood cells it displaces them in quite a characteristic manner, which is unlike the movement imparted by trypanosomes. From time to time a spirochaete joins end to end to form a ring, and then spins rapidly round, but in the course of a few minutes straightens out and moves in the ordinary way. Others remain motionless for a comparatively long time, and then suddenly start to move again.

The body of the spirochaete in section would look more like a flattened band than like a cylinder. On looking at the parasite an alternation of broader and thinner portions is often seen, the broader parts with ill-defined edges. This appearance is apparently due to a difference in the refraction of the various parts of the spirochaete. They are thinner than the greatest depth of a red blood cell, and consequently the spirals can move up and down in a space equal to this. At a given moment, therefore, the spiral turns of a parasite will be in different planes and thus not all in focus. Those which are out of focus accordingly appear to be broader than those which are in focus.

Along the course of the spirochaetes from six to eight dots which are much more refractile than the general protoplasm can be seen occasionally; most of these are in the uppermost part of the spirals. The width of the single spiral turns of a spirochaete as seen in stained specimens varies with the method of preparation. When the films are exceedingly thin, or are made on warmed slides, the turns are much broader and are fewer in number than when unheated slides are used, three or four as compared with ten to twelve in slowly drying specimens, *e.g.*, in organ films especially. When observed under very high magnifications with monochromatic light, a shadow

was seen passing along the edge of the spirochaetes, but we hesitate to say that this was caused by an undulating membrane, as we have never been able to see such a structure in stained specimens.

Zettnow[41] had described in *Spirochaeta duttoni* and Borrel[3] in *Spirochaeta gallinarum* peritrichal flagella. Although many specimens were examined particularly to this end no evidence of such a condition was ever found. The erythrocytes are extremely plastic and change their shape under the slightest influence, but this was never observed to occur even when the parasites were in very close contact with the red blood cells. Spirochaetes were often seen closely coiled round erythrocytes, but caused no change in their shape such as would be expected to follow were lateral flagella present.

It was impossible to make out any definite structure in fresh specimens. Different reagents which bring out the nuclei of cells were employed, but no changes were noticed in the spirochaetes.

STAINED SPECIMENS

The spirochaetes stain readily with all the modifications of Romanowsky's stain and with some of the basic stains. The individual parasite is then found to measure from 14 to 16μ in length, but chains of three or four are often seen measuring up to 45μ. In specimens which have been stained for a fairly long time the spirochaete is seen to consist of a darkly-stained central core surrounded by a very thin layer of faintly-staining periplast. This periplast extends beyond the termination of the more deeply-stained central portion, and is gradually drawn out to a pointed extremity at one end of the parasite. This forms, in our opinion, what other observers have described as the terminal flagellum.

In a short note on the structure of *Spirochaeta duttoni* Stephens[33] has described "eviscerated forms" produced by mechanical or chemical action on the parasite. Probably these are produced by a separation of the periplast from the central part of the spirochaete.

The chromatic core does not stain evenly; in very many spirochaetes darker portions alternate with lighter ones. Frequently a small unstained area can be seen to completely interrupt the core of chromatin, and is usually situated in about the middle third of the body.

Peculiar forms are seen most often in the "decline" blood. The chromatic core appears to be broken up into from six to eight small portions which stain deeply by Giemsa's method.

Particular reference may be made to a form which was found occasionally in films made from the liver and spleen. In this the spirochaete is coiled up into a small compass, stains a deep red with Giemsa's stain and is surrounded by a well-stained membrane. The whole structure is about three-quarters the size of a red blood cell. The space between the membrane and the spirochaete is filled with a faintly-stained pink substance. We are unable to give any explanation of the origin of this body, but suggest it may be an encysted form (Plate VIII, Fig. 21, page 96).

XIV. Protozoal Nature of Spirochaetes

Novy and Knapp [24] believe that they have brought the final proof of the bacterial nature of *Spirochaeta obermeieri*, and Borrel[3] places all the spirochaetes in the group of spirilla or spirillo-bacteria. Blanchard [2] places these organisms among the protozoa. In his latest publication Prowazek[29] states that he has seen in *Spirochaeta gallinarum* longitudinal division, the presence of an undulating membrane, and the penetration of the parasites into young and old red blood cells which are more oval than normal, and contain granulations in addition to the spirochaetes. He calls the parasite real "Zellparasiten," and states that this speaks against the bacterial nature of the organisms.

The course of the disease in experimental animals is quite different from any bacterial infection known at present. No bacterium causes such a regular recurrence of relapses as do the spirochaetes, and it is a remarkable fact that several rats inoculated from a patient during the interval, when no parasites could be seen in the peripheral blood, became infected *coincidently with the onset of the succeeding relapse*. This points distinctly to a life-history of the spirochaete in the host.

The occurrence of active immunity is not a certain indication of the bacterial nature of an organism, as it is well known that protozoa are capable of conferring this condition, *e.g.*, rats which have passed through an infection with *Trypanosoma lewisi* are immune afterwards, and malaria confers a relatively active immunity. We

have not been able to protect a single susceptible animal against spirochaetal infection by the use of immune and hyperimmune serum.

As the result of their investigations, Dutton and Todd[8] state that the transmission of the spirochaetes by ticks is not merely mechanical and that some developmental process takes place in the tick. The passage of the spirochaetes from the alimentary canal of the ticks to the ovary and eggs is a very interesting and suggestive fact.[12] This has not been shown to occur in the case of any bacterium up to the present, but is known to occur with protozoa.

XV. Animal Reactions of Sp. obermeieri

The experiments given below were carried out with a strain of spirochaetes derived from a case of relapsing fever in the Bellevue Hospital, New York, and is the same as that on which Novy and Knapp based their observations.[23, 24] These observers have identified it as *Spirochaeta obermeieri*. We have used only monkeys and rats as Norris, Pappenheimer and Flournoy,[19] and Novy and Knapp[24] have dealt fully with the animal reactions of this spirochaete.

MONKEYS

The incubation period in monkeys varied between one and four days, depending upon the amount of infected blood with which they were inoculated. The attacks varied in length from two to six days. As a rule only one relapse occurred, but occasionally two were noted. The infection was very similar to that with *Spirochaeta duttoni*, but the first relapse usually occurred after a longer negative interval than seen in the case of the African strain. As many as twenty-two days elapsed between attack and relapse.

RATS.

Rats became infected in from twelve to twenty-four hours in the majority of cases, but prolongations of the incubation period up to eight days, in one case, have been observed. The attack lasted from one to three days, as a rule, occasionally four, and the spirochaetes were usually found in the preparations in small numbers. At the height of the attack the maximum number observed was twenty to a field, and this was seen in only a very few cases; in most of the rats one spirochaete to 2-10 fields was found. Relapses were observed in

61 % of 60 rats watched specially for this purpose. The relapses were of very short duration, usually one day only, and very few spirochaetes were present in the peripheral circulation, only one or two in a preparation. In two cases the rats had two relapses each. In the one rat the first relapse occurred on the second day after the attack ended, and the second sixteen days after the first. In the other a negative interval of two days elapsed between the attack and the first relapse, and ten days between the two relapses.

The peripheral blood remains infective after the spirochaetes have disappeared from the circulation, as will be evident from the following:—

A rat which had an attack lasting three days was killed on the fourth day on which no parasites had been found in peripheral blood. Another rat was inoculated from it and became infected after an incubation period of three days. This observation has been repeated in other cases.

The blood was always infective on the day after the spirochaetes had disappeared—at later periods only if larger doses were used. The disease has never been followed by a fatal termination in any animal.

MICE

A few mice were inoculated with this strain and proved to be more susceptible than rats. The disease was more severe than in rats, and two relapses were observed very frequently.

The above experiments show **that the animal reactions of** *Spirochaeta obermeieri* **are quite different from those of** *Spirochaeta duttoni*. The objection may be raised that this difference was due only to a difference in virulence of two strains of the same parasite, brought about by very numerous passages through susceptible animals. Every effort was made to increase the virulence of *Spirochaeta obermeieri* both by slow and quick passage through rats, but always without result. In one rat inoculated with infected blood which had been kept *in vitro* for fifteen days, the attack was of longer duration and was more severe than previously seen, but the rats subinoculated from this suffered the usual slight and passing infection. Moreover, as has been stated already, the strains of African spirochaetes derived from monkeys infected directly by the bites of ticks were just as virulent as others which had been passed through long series of rats.

Novy and Knapp state that they have never seen a relapse in rats. **Our experiments show that if the examination is done carefully enough and is continued for a sufficiently long period, relapses are found to occur in the majority of the cases.**

XVI. Active Immunity in Sp. obermeieri

The monkeys which had recovered from the disease were reinoculated with the same strain, and this resulted in much the same manner as noted in the similar infections with the African spirochaete.

In one case the subinoculation of a white rat on the first day after the reinoculation of the monkey was followed by infection. Two parasites were seen in preparations of the monkey's blood. Subinoculations were made some days later, but the rats did not become infected. Five rats were reinoculated after complete recovery, and of these two became infected.

A rat which had recovered from an attack with one relapse was reinoculated six days after the first inoculation with 5 ccm. of infected blood. Two days later scanty spirochaetes were found in the peripheral circulation, and then disappeared finally.

Another rat which had passed through a very slight attack lasting one day was reinoculated nine weeks afterwards, and was infected for two days after an incubation period of one day. The parasites were very few in number.

Three other rats did not become infected when reinoculated at periods varying between five and seven weeks after the original attack.

Animals which have recovered from infection by *Spirochaeta obermeieri* acquire a certain amount of active immunity against reinfection, the efficiency of which corresponds directly to the severity of the attack.

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*Gabritschewsky 9 was able to infect rats, white mice and a guinea-pig with *Spirochaeta obermeieri* derived from a case of relapsing fever occurring in Russia. The disease was very mild in the rats.

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NOTE ON A NEW SPIROCHAETA FOUND IN A MOUSE

NOTE ON A NEW SPIROCHAETA FOUND IN A MOUSE*

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The spirochaete described below was found in the blood of a white mouse infected with *Trypanosoma dimorphon*, which was sent from Paris by Professor Laveran. We take this opportunity of expressing to him our sincere thanks for permission to publish these observations.

In the fresh, the spirochaete imparts a movement to the red blood cells similar to that found in the case of other spirochaetes. The parasite is very small, translucent and actively motile, and shows both a movement of the spiral turns and a progressive movement of the whole organism between the blood cells. Occasionally the spirochaete appears to become fixed at its centre and then rotates round an axis at right angles to its length. It stains readily with any of the aniline dyes and all the modifications of Romanowsky's stain, and then appears as a short, plump, uniformly-stained spirochaete. Long and short forms occur, measuring between 1·8 and 3·75 μ in length and 0·1 and 0·2 μ in breadth. The number of spirals varies between two and four, and there is also a variation in the size of the spirals in different parasites. Both ends are drawn to a point, one usually more abruptly than the other (Plate VIII, Fig. 20).

* This article is reprinted from the Lancet, September 8th, 1906, with additional observations. We learn, from a communication recently published in a medical journal, and from private correspondence, that this parasite is one with which Dr. W. C. Wenyon has been working for some time at the Pasteur Institute, Paris. We regret that we have inadvertently anticipated him in publishing our observations.

The parasites were very scanty. In the fresh, only one or two were seen in a preparation, while in the stained one spirochaete in from twenty to forty fields (Zeiss, oc. 4, $\frac{1}{12}$ oil immersion) was counted.

We have been unable to find in the literature any reference to a spirochaete of mice. Vandyke Carter[1] describes a spirochaete observed in an Indian rat, but this parasite is longer and possesses more spiral turns than the one described above. As this appears to be a distinct species, we propose for it the name "*Spirochaeta laverani*" (n. sp.).

The spirochaete can readily be transmitted by inoculation from mouse to mouse. The incubation period varies between four and five days, and the parasites remain present in the peripheral blood for several weeks. Rats are also susceptible to infection by this parasite. The incubation period is 5-6 days.

Of six wild mice, *Mus musculus*, caught around the laboratory two were infected with this spirochaete; both of them appeared to be sick. All the transmission experiments were made with the strain derived from these wild mice.

The only post mortem finding was enlargement of the spleen.

Attempts to transmit these spirochaetes by means of fleas and lice collected from infected animals have so far been unsuccessful.

REFERENCE

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A COMPARISON BETWEEN THE TRYPANOSOMES PRESENT BY DAY AND BY NIGHT IN THE PERIPHERAL BLOOD OF CASES OF HUMAN TRYPANOSOMIASIS

A COMPARISON BETWEEN THE TRYPANOSOMES PRESENT BY DAY AND BY NIGHT IN THE PERIPHERAL BLOOD OF CASES OF HUMAN TRYPANOSOMIASIS

Sixth Progress Report of the Expedition of the Liverpool School of Tropical Medicine to the Congo, 1903-1905.

BY

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If preparations of blood from the peripheral circulation of cases of human trypanosomiasis be examined daily, it will soon be seen that the number of parasites varies greatly.[1,2] It will also be noted that this variation shows no regular periodicity in time, neither does it seem to bear any intimate relation to the clinical course of the infection.[3,4]

The following observations were made to ascertain whether more minute variations occurred in the number of trypanosomes present in the blood of sleeping sickness patients than could be determined by daily examination, and to ascertain whether the parasites were more numerous in the daytime or at night.

At Leopoldville, in June, 1904, five selected cases of human trypanosomiasis were examined at intervals of three hours during a period of twenty-four hours (Table I).

At Kasongo, in February, 1905, five more cases were examined at intervals of four hours during a period of seventy-two hours (Table II).

At each examination fresh coverslip preparations of blood were made, and in addition the blood was centrifugalised. Films for staining were made from both fresh and centrifugalised blood, for the purpose of observing whether there were any morphological differences between the parasites present in the peripheral circulation in the day and at night. Unfortunately, the number of parasites found in our preparations was not sufficiently large to permit any definite assertion on this point; stained trypanosomes have only been found in slides of blood from Molumba and Kahambwe. A careful comparative examination of these slides showed that the organisms seen could be divided, according to their length, into two groups, one of longer, the other of shorter forms. There were, however, individual variations; one long form was one-sixth as long again as the other parasites of the same type. Dividing forms were seen in equal numbers in the day and at night; all that were seen resembled the longer type.

The shorter form measured $17 \cdot 7\mu$ by $1 \cdot 2\mu$. The blepharoplast was placed, as a rule, at the tip of its rounded posterior extremity; its cytoplasm stained darkly, and the whole parasite seemed to have a denser structure than the long form. The longer form measured $26 \cdot 3\mu$ by $1 \cdot 6\mu$; both its body and nucleus stained more palely and had a looser structure than had the shorter form. Both types of parasite occasionally showed chromatic granules in their cytoplasm.

A comparison of our slides showed that long and short forms occurred in equal numbers in films made during the daytime; but there were slightly more long than short forms in films taken at night. This difference, however, was so slight that no importance can be attached to this observation. We, therefore, conclude that no marked morphological difference existed, in these cases, between the trypanosomes present in blood films taken in the day and at night.

Tables I and II show the results of examination of the fresh blood. An inspection of them indicates that trypanosomes were slightly more numerous during the day than at night. The difference is slight, and we conclude that trypanosomes occurred in the peripheral blood of these cases in practically equal numbers during the day and night.

In Table I the number of Filaria seen in the patients' blood is mentioned since these observations suggest the relative efficiency of the examination of fresh coverslip preparations and of centrifugali-

sation in the detection of blood parasites.[5] In the case of Toleki the periodicity of *Filaria diurna* is demonstrated. Had there been any similar periodicity in the occurrence of the trypanosomes it would therefore probably have also been observed.

The record of the examinations of Makava and Yuma show once again how difficult it frequently is to find trypanosomes in the blood of sleeping sickness cases.

Greig and Gray[6] have obtained results which seem to indicate that trypanosomes are more numerous in the blood of sleeping sickness patients in the night time. Their observations do not seem to have been sufficiently complete to permit a definite conclusion.

It may be suggested that since the amount of blood contained in our preparations was not accurately measured the number of parasites present in them cannot properly be compared, and, therefore, that the figures given in our tables do not represent the actual variation in the number of parasites present in the blood of our patients. In making our coverslip preparations and centrifugalisations care was always taken to use, as nearly as possible, a similar amount of blood.

With care the amount of blood used in making coverslip preparations, particularly, varies very slightly. The amount of blood used in centrifugalising is less constant; here, too, variations in technique are more frequent. On the whole, however, we believe that our methods were quite accurate enough to detect any marked variation in the number of parasites had it existed, and therefore sufficed for the purposes of this enquiry.

It had been noticed that occasionally trypanosomes seemed to be more numerous in the blood of our Sleeping Sickness patients on very warm days. It was, therefore, thought that the very slightly increased numbers of trypanosomes present during the daytime in the cases mentioned in this paper might have been due to the higher diurnal temperature. (At Leopoldville, maximum during the day 29·4° C., maximum during the night 20·3° C.; at Kasongo, 30° C. and 19·2° C.) To determine whether temperature had any influence upon the number of parasites present in the blood obtained from the peripheral circulation of an animal infected with *Trypanosoma gambiense*, a heavily-infected guinea-pig was examined carefully at room temperature (20° C.). It was then confined for three hours in a cold incubator at 12° C., and immediately afterwards for a second three

hours in a hot incubator at 40° C. There was no perceptible alteration in the number of parasites in blood taken from the ear.

From a consideration of the observation recorded in this paper it is concluded that:—

No marked qualitative or quantitative change, corresponding to day and night, occurred in the peripheral blood of the cases of human trypanosomiasis mentioned in this paper.

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TABLE I.—NUMBER OF PARASITES PRESENT IN A COVERSLIP PREPARATION

JUNE 14, 1904		DAY								NIGHT							
		9 a.m.		12 a.m.		3 p.m.		6 p.m.		9 p.m.		12 p.m.		3 a.m.		6 a.m.	
		Coverslip* Preparation	Centrifugalised	Coverslip Preparation	Centrifugalised	Coverslip Preparation	Centrifugalised	Coverslip Preparation	Centrifugalised	Coverslip Preparation	Centrifugalised	Coverslip Preparation	Centrifugalised	Coverslip Preparation	Centrifugalised	Coverslip Preparation	Centrifugalised
MOLAR ... ... (*Advanced case*)	Trypanosomes ...	...	4	...	1	...	2	...	1	...	...	...	...	...	...	...	...
	Filaria perstans...	...	...	...	...	...	...	...	1	...	1	...	2	...	...	...	...
	Sheathed filaria...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
KITAMBALA ... (*Advanced case*)	Trypanosomes ...	...	2	...	1	...	...	...	...	...	...	...	...	...	...	...	...
	Filaria perstans...	7	42	12	43	14	69	6	80	4	46	16	26	7	20	10	48
	Sheathed filaria...	...	3	...	...	1	1	...	...	...	...	...	...	...	...	...	...
MOLUMBA ... ... (*Advanced case*)	Trypanosomes ...	2	very many	2	num-erous	1	num-erous	...	160	1	†	1	10	4	†	...	14
	Filaria perstans...	1	16	2	9	11	many	1	13	...	...	7	24	3	...	2	8
	Sheathed filaria...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
TOLEKI ... ... (*Early case*)	Trypanosomes ...	...	5	...	2	...	...	...	...	...	...	...	...	...	...	...	...
	Filaria perstans...	...	1	2	5	1	3	2	10	...	...	...	2	1	2	...	4
	Sheathed filaria...	4	10	2	24	2	23	5	54	5	13	...	1	...	1	...	2
MAKAVA ... ... (*Early case*)	Trypanosomes ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Filaria perstans...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Sheathed filaria...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Three-quarter inch square coverslip. Negative examinations are not indicated in this table.

† Signifies not examined.

TABLE II.—NUMBER OF TRYPANOSOMES PRESENT TO A COVERSLIP* PREPARATION

		February 2, 1905						February 3, 1905						February 4, 1905						February 5, 1905					
		8 a.m.	12 a.m.	4 p.m.	8 p.m.	12 p.m.	4 a.m.	8 a.m.	12 a.m.	4 p.m.	8 p.m.	12 p.m.	4 a.m.	8 a.m.	12 a.m.	4 p.m.	8 p.m.	12 p.m.	4 a.m.	8 a.m.	12 a.m.	4 p.m.	8 p.m.	12 p.m.	4 a.m.
PANIA ... (*Advanced case*)	Coverslip Preparation	...	...	...	2	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	†	...	...	...	...
	Centrifugalised	12	3	1	6	3	3	3	20	2	18	2	...	2	2	4	4	2	6	...	...	...	...	...	...
KAHAMBWE (*Advanced case*)	Coverslip Preparation	...	†	...	...	...	...	...	2	...	...	...	...	...	...	2	...	2	...	...	...	2	...	...	...
	Centrifugalised	...	...	...	2	3	1	40	28	4	7	19	7	21	110	100	26	18	6	50	60	20	...	...	...
BAROUTI ... (*Early case*)	Coverslip Preparation	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	†	...	...	...	...
	Centrifugalised	7	5	...	...	...	...	2	1	...	...	...	5	1	...	...	...	...	...	...	...	...	...	...	...
YUMA ... (*Early case*)	Coverslip Preparation	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Centrifugalised	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
KAMOKO ... (*Late case*)	Coverslip Preparation	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...
	Centrifugalised	...	...	...	...	2	2	1	2	...	...	1	1	2	1	1	3	1	1	...	...	...	...	...	...

* Three-quarter inch square coverslip. Negative examinations are not indicated in this table.

† Signifies not examined.

THE LESIONS IN THE LYMPHATIC GLANDS IN HUMAN TRYPANOSOMIASIS

CONTENTS

THE LESIONS IN THE LYMPHATIC GLANDS IN HUMAN TRYPANOSOMIASIS*

BY

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Introduction

1. The purpose of the following paper is to describe the changes that take place in the lymphatic glands in human Trypanosomiasis. The glands on the examination of which the paper is based were taken from the cervical and inguinal regions of natives of West and Central Africa, suffering from "Sleeping Sickness." For the material I am indebted to Dr. J. L. Todd, of the Liverpool School of Tropical Medicine, who with the late Dr. Dutton excised the majority of the glands.

For convenience of description the glands will be divided into three groups; in the first will be placed cervical glands taken from a very early case, under the care of Dr. Latchmore at the Colonial Hospital, Freetown, Sierra Leone, who showed practically no symptoms of the disease; thirteen glands were examined. In the second group will be placed cervical glands excised from later cases, the symptoms of the disease being more or less marked; twenty-six glands were examined. In the third group will be placed inguinal glands also taken from a later case; five were examined.

The glands of the first group were excised during life, and were placed at once in a saturated solution of Corrosive Sublimate + 4 % acetic acid, and afterwards preserved in 40 % alcohol. The glands of the second group were also excised during life, and placed immediately in absolute alcohol. The glands of the third group were excised at a post mortem examination held while the body was still warm. They were fixed in absolute alcohol.

For staining there were employed Delafield's haematoxylin, haematoxylin and eosin, Van Gieson's stain, Romanowsky's stain, and finally Ehrlich's triacid stain.

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* This paper was originally presented as a thesis for the Degree of Doctor of Medicine in the University of Liverpool. The observations on which it is founded were commenced in November, 1905; the paper was presented for publication in July, 1906.

2. Group I.

Cervical Glands excised from a very Early Case

The most noticeable feature in these glands is the widespread occurrence of germ centres. In sections of the normal human gland, even in young subjects, it is by no means uncommon to find no evident germ centres, while in glands from cases of trypanosomiasis no section was cut that did not contain them, and, generally, they occupied a considerable area of every section. They were distributed in all parts of the gland more or less evenly, and in sections stained with haematoxylin were quite visible to the naked eye as blue spots. They varied both in shape and size, though for the most part they were round in section. The centres were sometimes surrounded by concentric layers of lymphocytes, staining deeply as compared with the cells composing the centre; at other times the lymphocytes at the periphery were arranged more irregularly. In all cases, the germ centres in these early glands were sharply marked off from the surrounding tissue. The nuclei of the cells composing the centre presented various appearances; as a rule they were stained faintly, but in each there were one or more condensations of chromatic material that took on a deeper tint. Karyokinetic figures were very common in the centres, and nuclei showing these figures were always conspicuous by staining more deeply, so that it was quite easy to pick out the cells that were undergoing division. In one centre twenty mitotic figures were counted in a field (Zeiss, $\frac{1}{12}$ achromatic objective, No. 9 ocular). The cells of the centre were larger than the surrounding lymphocytes, but here and there amongst them a lymphocyte of ordinary size was noticed. Some of the glands were undergoing a curious structural alteration which will be referred to later, and in these the germ centres were not so numerous, and mitosis was not so common. The accompanying micro-photograph illustrates the widespread occurrence of the germ centres (Plate VI, Fig. 1).

In most of the glands of this group red blood corpuscles were found lying free either in the peripheral or central sinuses, or amongst the lymphocytes of the gland. Although in a few of the early glands examined, the sinus system was quite pronounced, and approximated to the condition found in the glands of the next group, yet, generally speaking, it did not differ very materially from that of the normal

gland, except in the nature of the cells found within it; it was situated under the capsule, but rarely, if ever, completely encircled the gland, interruptions being caused by lymphoid tissue. It also accompanied the trabeculæ, and was found in the central parts of the gland. If we accept the definition of a haemolymph gland given by Warthin in his paper contributed to the *Journal of Medical Research* (July-December, 1901), and entitled "A contribution to the Normal Histology and Pathology of the Haemolymph Glands," viz., a gland with a sinus containing blood instead of lymph, these glands may nearly all be termed haemolymph glands, though they do not entirely satisfy the requirements of the definition, for neither in the early stages nor in the later is the lymph of the sinus entirely replaced by blood. As will be seen hereafter, however, the presence of blood lying free in the trypanosomiasis glands is one of their most marked and constant features, and one on which may depend some of the other structural changes either in the gland stroma or its cellular contents.

Warthin states, moreover, in the article referred to, that while haemolymph glands are most commonly found in the neighbourhood of the renal vessels, and in the retroperitoneal fat, their next most common situation is in the cervical region, below and behind the lobes of the thyroid. This fact should be remembered before concluding that the presence of free erythrocytes in glands from the neighbouring posterior cervical triangles is entirely pathological.

The sinuses of the glands in this group were for the most part occupied by a coarse adenoid reticulum, and there were seldom, if ever, open spaces such as were sometimes found in the later stages. In a few cases no red blood corpuscles were found in the sinuses, in others they were more plentiful. Haemorrhages were not uncommon, both capsular and subcapsular as well as in the gland substance, though some of these were possibly artificially produced.

In addition to the red blood corpuscles, a few large mononuclear cells containing blood pigment were present, and a little free pigment was noticed.

It was sometimes difficult to distinguish between a capillary vessel and a small sinus; Breinl in his paper contributed to the Thompson Yates Reports, Vol. VI, Part 2, states that the point of distinction lies in the fact that the sinuses are not lined by endothelial cells as the

blood vessels always are. In the glands under consideration the sinuses were always lined by endothelium; the main point of difference appeared to be the fact that even a small sinus had usually some reticulum within it, while the capillary contained only free cells. At the same time, in many of the glands, even of this group, one or more sinus-like spaces were observed lined by endothelium and containing red blood corpuscles, lymphocytes and coagulated fluid, with apparently no reticulum at all.

The capsule was variable in thickness, but for the most part normal, sometimes containing fat cells, and as already noticed was often infiltrated with blood; it was moderately vascular. From it extended into the gland somewhat broad trabeculæ, some of which contained large vessels. The hilum also was sometimes composed of fairly dense fibrous tissue, and contained vessels and blood spaces; in these the number of lymphocytes mingled with the red blood corpuscles was extraordinary.

Before bringing the account of this group of glands to a close, one further point of structural change must be noticed. The change in question was hardly less constant than the increased occurrence of germ centres. It was present in some glands to a greater degree than in others; in a few cases it was somewhat diffuse (Plate VI, Fig. 2); generally, however, it was localised to one or more areas of the gland. Under a low power of the microscope, it was noticed that small portions of the gland, of no particular shape, and somewhat ragged and irregular in appearance, were stained very deeply with basic dyes such as haematoxylin, methylene blue or haematein. Under high powers, these deeply-stained areas appeared to be composed of fine filaments or irregular pieces; but if a part was found where the change was commencing, there were seen to be amongst the normal lymphocytes others whose nuclei were somewhat elongated and which had become fusiform, whilst near these again there were long, spindle-shaped filaments with a somewhat thicker centre and tapering extremities. The same change was noticed in the glands excised at a later period of the disease, and will be referred to when these glands are described.

The connective tissue stroma of the glands was not noticed to be much increased, but occasional mitosis in the nuclei of the stroma cells was observed.

In the capsule as well as in the substance of the gland were noticed little collections of dark dots, which may be aggregations of old blood pigment due to previous malarial infection.

3. GROUP II.

Cervical Glands excised from Later Cases

The changes to be described in these glands are very much more marked than they are in the glands of the first group. While the latter were taken from a patient who did not show any symptoms of "Sleeping Sickness," the former were taken from people all of whom showed symptoms of the disease in a more or less marked degree. In the case of one patient, Tschomba, a lad of seven, however, the disease was still in its initial stage, and it is a remarkable fact that, in his case alone, none of the glands showed extensive sinus formation. His glands, and also some taken from the other cases approximated in structure to the first group in this respect, at any rate, that the glands were for the most part solid.

The glands of Tschomba will first be described. Their capsule was thin, and there was some distinction of the gland substance into cortex and medulla; underneath the capsule was a cortex composed of a broad, darkly-staining zone of closely packed lymphocytes, and within this the medullary portion was situated, more lightly stained, and containing fewer cells. Immediately beneath the capsule was the peripheral sinus, incomplete as usual, and containing lymphocytes, red blood corpuscles and polymorpho-nuclear leucocytes. A few small sinuses traversing the cortical region passed through the centre of the gland. Red blood corpuscles were found distributed throughout the glands, amongst the lymphocytes. The glands possessed a hilum composed of loose connective tissue, with many large vessels, both veins and arteries, which contained a considerable proportion of leucocytes and coagulated fluid. A few germ centres only were present showing slight mitosis. There was a great increase of connective tissue stroma in the gland, and throughout it there was a large number of polymorpho-nuclear leucocytes both free and in the blood vessels. There were large mononuclear cells scattered throughout the gland in which mitotic figures were observed. The structural change alluded to above, an apparent transformation of the nuclei of the lymphocytes, was again present, as in the glands of the first group.

In many of the remaining glands of this group the departures from the normal were more noticeable. The germ centres will be first dealt with. These were fewer in number though still comparatively numerous, but their size and shape were more variable, being on the whole larger and more irregular; they were not visible to the naked eye, and were not so sharply defined from the surrounding tissue. There was still a good deal of cell-division, though not, on the whole, so much as in the earlier glands. The germ centres, too, were more variable in position, and were more unevenly distributed; especially was this the case where there was marked sinus formation, the centres being then generally situated in the more solid part of the glands, which was often in these cases the peripheral cortical zone. The centres were more evident when Romanowsky's stain was used, they then appeared as pale blue areas under low powers. Occasionally they were quite small, in other cases they appeared to be in a state of degeneration—the cells being irregular in shape and of abnormal appearance; mitotic figures were then absent. Mitotis was not uncommonly noticed in the lymphocytes of the general gland tissue, and in certain of the leucocytes contained in the peripheral and central sinuses.

The capsule in these glands still varied in thickness, but it was generally thicker than in the glands of the first group. Moreover, in the subcapsular region of several of the glands, a structural change was noticeable, which apparently denoted the occurrence of an actual increase in thickness. Underneath the capsule, which was stained a brilliant pink by Van Gieson's method and by eosin, there was a broad zone of cells whose nuclei stained a deep blue by either haematoxylin or methylene blue, and were for the most part spindle shaped. Amongst them were found ordinary lymphocytes and in some cases polymorpho-nuclear leucocytes. The nuclei were for the most part of the size of lymphocytes; towards the capsule proper, the small spindle-shaped nuclei became further elongated until they seemed to be transformed into those of fibre cells. Occasionally the picture was still more striking; the lymphocytes could almost be seen arranging themselves, as it were, beneath the blue cell zone. More internally still mitosis was observed in the lymphocytes—lymphocytes not contained, in this case, in definite germ centres. Further, the capsule proper, in one or two cases, stained differently in its internal and

external portions when Van Gieson's stain was used. The outer, older portion took on a yellow colour with the picric acid, while the inner and more recently formed portion stained pink with the fuchsin. The above process was apparently not associated with any new formation of vessels, nor was there present any marked mitosis in the nuclei of the cells making up the connective tissue stroma of the gland, though such mitosis could be noticed here and there. The accompanying micro-photograph illustrates the process above described (Plate VI, Fig. 3). This subcapsular change is not present in the early glands nor in those of Tschomba, neither is it present in Group III, where apparently the capsule thickening has reached its limit.

Associated with this capsular sclerosis, there was a general increase of fibrous tissue throughout the gland. The trabeculæ were large, and occasionally islands of lymph tissue were seen surrounded by dense fibrous tissue. It has already been noticed that the nuclei of the cells of the adenoid reticulum not uncommonly showed karyokinesis, and sometimes the cells contained two large nuclei.

The curious structural change before alluded to, both in describing the glands of Group I and in those of Tschomba, was constantly present, in some cases, to a marked extent. Sometimes it was observed to occur at the end of trabeculæ that passed into the centre of the gland from the circumference. At other times it was associated with the capsular thickening above described. This association suggested that possibly the two processes were of a similar nature. Up to the time that this association was first noticed, it was regarded as a mucous degeneration. While, however, it stained well with basic dyes, it did not react characteristically to muci-haematein or muci-carmin. Whatever may be the significance of this structural change in the glands, it is a very remarkable fact that it was present in almost every gland examined.

The following paragraph taken from an article on "The Rôle of the Lymphocyte," by Burton Clellan (contributed to the Transactions of the Pathological Society of London, July, 1905), is of considerable significance in connection with the sclerosis of these glands:—

"Various observers have, at different times, satisfied themselves "that lymphocytes may be converted into cells like those of the "'fixed cells' of an irritated part, and may then proceed to

"organisation. Thus Dr. Mott, F.R.S., at the recent meeting of the "British Medical Association at Leicester, figured all the stages in the "conversion of lymphocytes into plasma cells. I have myself traced "the passage of the latter into fibrous tissue cells."

Sometimes this process was associated with the presence of large blood-vessels or with red blood corpuscles lying free in sinuses near by, but there was apparently no new formation of vessels, nor was the near presence of blood constant. It has to be remembered, however, that in the majority of these glands the tissue contains a good deal of free blood.

When one asks the question what is the significance of the huge lymphocyte formation that takes place in these glands, there seems no very clear answer. To assign to the lymphocyte some function in the process of sclerosis would be to account for part at any rate of the extraordinary manufacture of these cells. Along with the process of sclerosis, there is apparently one of rarefaction, for while the earlier glands appeared more or less solid structures, some of the later ones showed marked sinus formation. The amount of this sinus formation varied much; in some glands the central part was more lightly stained than the remainder, and here under a high power could be plainly seen the sinus system much more highly developed than in the earlier glands. There was as before a peripheral sinus always incomplete and not always well marked, which communicated with the central sinuses. The amount of adenoid reticulum in the sinuses also varied greatly; occasionally glands were met with having very little reticulum, and displaying a series of spaces containing different kinds of leucocytes along with red blood corpuscles. The position of the sinuses was not constant, sometimes they occupied the immediate neighbourhood of the hilum, at others a small portion of gland near the periphery would be marked out by sinus formation, the rest of the gland being more or less normal. Never in the glands of this group was the whole of a gland transformed into sinus-like spaces, as we shall see to be the case in the glands of Group III, still to be described. The sinuses were in all cases lined by endothelium (Plates VI and VII, Figs. 4 and 9).

The contents of the sinuses were found to be much as Breinl described them. Lymphocytes of the small variety were the most numerous content; besides these, there were present large

lymphocytes, and large mononuclear cells with a good deal of protoplasm. Polymorpho-nuclear leucocytes were abundant, and transitional forms were also represented. Leucocytes containing blood pigment, coarsely granular eosinophile cells for the most part doubly nucleated, and a few large cells containing blood corpuscles and vacuoles were also present. The last named were comparatively rare, and not anything like so numerous as in the glands Breinl examined, nor as in the inguinal glands to be hereinafter described. Mast cells were occasionally met with. Red blood corpuscles were nearly always present in smaller or greater numbers, but they were never massed together as in the haemolymph glands of animals. In addition to the cellular elements, the sinuses were often partially filled with coagulated fluid. Occasionally red blood corpuscles were noticed of various sizes, some being apparently degenerated and breaking down; but as noticed previously, in sections of some glands, no red blood corpuscles whatever were present in the sinuses. The red cells also occurred throughout the general tissue of the gland amongst the lymphocytes.

The number of polymorpho-nuclear leucocytes in some of these glands was extraordinary. They were found in great numbers in the peripheral and central sinuses, and in glands that had no well-marked sinus formation they occured in the stroma—sometimes in the parts of the gland in which apparently sinuses were to be developed. In the accompanying micro-photograph (Plate VI, Fig. 5) one such area is illustrated. Further these cells were very numerous in the capillaries of the gland, and as noticed previously, they were found amongst the spindle-cells apparently concerned in the thickening of the capsule. Both they and the eosinophile cells now to be described would seem to be the sign and seal of the inflammatory changes taking place. The question has often presented itself as to how the formation of the sinus spaces takes place; a digestive function on the part of one or more of the numerous leucocytes occasioning in these glands might be assumed, but would be hard to prove.

The occurrence of the eosinophile cells in some of the glands was also very remarkable. Thirty have been counted in one field (Zeiss, $\frac{1}{12}$ achromatic objective, No. 4 ocular). As a rule the cells were doubly-nucleated, though cells with one or three nuclei were also found. The granules were of the coarse variety and often almost

obscured the nuclei. These cells were found in the small vessels of the gland, in the sinuses, and in the general gland tissue. They were usually noticed in conjunction with red blood corpuscles, and the granules of the former stained with eosin the same pink colour as the protoplasm of the latter. Breinl in his paper mentions the fact that he has seen lying side by side cells containing remnants of red blood corpuscles and eosinophile cells in which the haemoglobin seemed to be crystallising out. The same conjunction was noted in one or two of the glands under consideration. They were found in close juxtaposition, one a singly-nucleated, coarsely-granular eosinophile cell, another a cell without a nucleus containing eosinophile granules, and, in addition, three or four bodies of unequal size, the largest having half the diameter of a red blood corpuscle; the third a cell without a nucleus containing fully formed red blood corpuscles and no granules. Occasionally in these glands, there were noticed little collections of coarse eosinophile granules apparently extra-cellular. The occurrence of both polymorpho-nuclear leucocytes and of eosinophile cells in large numbers in the capillaries of the gland has been noted. In a transverse section of a capillary, eleven eosinophiles, sixteen lymphocytes, and fourteen polymorpho-nuclear leucocytes were counted along with a few red blood corpuscles. The blood vessels of the hilum contained a great number of leucocytes, chiefly of the lymphocyte variety.

4. GROUP III.

Inguinal Glands excised from a Late Case

This group showed the most remarkable departures from the normal of any gland examined. They were excised from a boy aged about thirteen, shortly after death.

The most marked changes observed were a very extensive sclerosis, and sinus formation. The whole aspect of the glands was altered, though one could still trace a connection with the glands of previous groups.

The capsule was very thick and composed of dense fibrous tissue; it contained a few vessels. The hilum similarly was a mass of fibrous tissue from which trabeculæ of similar structure extended into the gland towards the capsule. In some cases half the gland was a mass

of fibrous tissue. The vessels found in the hilum were numerous and possessed of very thick walls (Plate VI, Fig. 6). It should, however, be added that the inguinal glands are usually more or less enlarged in the natives of Africa; the enlargement being in part due to new formation of connective tissue. The reason appears to be that from childhood the people are accustomed to go about with bare feet, and owing to cuts and wounds of various kinds the glands are constantly subject to inflammation.

Besides the sclerosis, there was observed a very remarkable sinus formation. A part of the whole of the gland was honeycombed, the sinus spaces occurring both between masses of lymphoid tissue and between bars of fibrous tissue. The reticulum of these spaces was variable in amount as in Group II; sometimes the spaces were quite open, at other times they were bridged across by adenoid reticulum. A portion of a gland is represented in the accompanying micro-photograph (Plate VII, Fig. 7) in which will be noticed a complete peripheral sinus as far as this end of the gland is concerned, and a great number of central sinuses.

The contents of these sinuses were even more remarkable than those previously found in Group II. The most striking feature was the occurrence in large numbers of huge cells containing many red blood corpuscles; as many as twelve or more erythrocytes were constantly found in these cells; in the accompanying micro-photograph (Plate VII, Fig. 8) these giant phagocytes may be easily seen. They occurred in all the sinuses. Sometimes they were singly-nucleated, but often had a number of nuclei. Giant cells containing six or more nuclei with or without red blood corpuscles were not uncommon; in them the nuclei were sometimes observed to show mitotic figures; in some cases the polynuclear giant cells seemed to arise from a proliferation of endothelial cells, as observed by Dorothy Reed in the glands in Hodgkin's disease. In some of these phagocytic cells corpuscles were noticed in a degenerated condition and in other cells there occurred blood pigment. Apparently these huge cells are concerned in the destruction of red blood corpuscles. In addition to these cells, there were large mononuclears, lymphocytes, red blood corpuscles, and other leucocytes in smaller numbers. Neither polymorpho-nuclear nor eosinophile cells were present. The accompanying micro-photographs (Plate VII, Figs. 8 and 9) represent

portions of the sinuses of (Plate VII, Fig. 7) as seen under higher powers. The giant mononuclear and polynuclear cells are well shown. They are in many cases filled with red blood corpuscles.

In these glands the germ centres which are so marked a feature of the glands in other groups have almost vanished. One or two degenerated remains were noticed, but these showed no mitosis. The function of the lymphatic gland as the "breeding ground" for lymphocytes has in these glands been abolished, apparently by the growth of the more lowly organised fibrous tissue.

In certain of these glands, necrotic areas were noticed of greater or less extent. In them the cellular elements were largely destroyed, bits of broken-down nuclei being included in a mass of poorly-staining almost structureless material.

General Conclusions

In conclusion a brief summary of the more important changes in these glands may be given.

1. There is in the early stages of human trypanosomiasis a remarkable and widespread increase of germ centres in the lymphatic glands accompanied by a corresponding multiplication of the proper cells of the gland. As the disease progresses the germ centres become less prominent, and not so evenly distributed in the gland. Cell division is still very noticeable, but on the whole the germ centres retrogress. This change may be partly due to the formation of the sinus system, and partly to the growth of fibrous tissue and ultimate sclerosis of the gland. Finally the germ centres are destroyed.

2. The ordinary lymphatic gland becomes in part a haemolymph gland.

What the signification of the determination of blood to the gland is, would be difficult to decide. The old controversy as to whether haemolymph glands are concerned in blood formation, or blood destruction, or both, is apparently still unsettled. The occurrence of phagocytic cells containing red blood corpuscles in a degenerated condition, and others containing pigment is certainly evidence of blood destruction. Warthin concludes in his paper referred to previously that normally "haemolymph glands are most probably concerned chiefly in haemolysis "and leucocyte formation. . . . In diseases in which the blood shows marked "changes, specific conditions are found in these glands of such a nature as to "place beyond doubt their blood-forming function."

Is the occurrence of the eosinophile cells one of the specific conditions that suggests a function of blood formation for these glands? It is a remarkable fact that while the eosinophile cells are present in the middle stages of the diseases,

they seem absent in those glands which apparently represent the latest stages and which contain the huge, red-blood-corpuscle-containing and destroying cells. And if it be true, as some hold, that the eosinophile cells have some connection either with blood destruction or blood formation—a connection that is based on the facts (1) that the eosinophile granules contain phosphorus and sulphur, as does the haemoblobin of the red corpuscles, and (2) that the eosinophile cells are found in great numbers in the marrow, the great red corpuscle forming organ—it would seem from an examination of these glands that the evidence is in favour of a blood-forming function. The remarkable conjunction which Breinl refers to, and which was observed in these glands, of eosinophilous cells, and red blood corpuscle-containing cells is suggestive of either a building up of eosinophile granules into the haemoglobin of the red blood corpuscle, or of the breaking down of the haemoglobin into these granules; but the absence of the eosinophilous cells from the glands where red blood corpuscles are being evidently destroyed is in support of the former process.

The occurrence in the glands of the eosinophile cells is of such interest that some further notice must be taken of it. In the article on "Anaemia," contributed by Ehrlich and Lazarus to diseases of the blood (Nothnagel's Encyclopedia of Practical Medicine), mention is made of the occurrence of eosinophilia in certain diseases, amongst which Chronic Skin Diseases and Helminthiasis are specially mentioned. Now, several of the patients from whom these glands were taken suffered from both Craw-craw, a chronic skin disease, and all had intestinal parasites. The authors of the above article incline to the chemiotactic theory of eosinophilia; the eosinophiles wander only to places which possess a substance specifically chemiotactic for them. If this be so, while the presence of skin and intestinal trouble might account for the occurrence of the eosinophilia, which is present in Human Trypanosomiasis in many instances, they would not account for the presence of the eosinophile cells in the glands in large numbers; though some of the cells might certainly find their way to the glands in the blood stream, and be passed on into the gland-sinuses.

That the trypanosomes are found in the lymphatic glands is now well known, and it might be inferred that certain products of their metabolism would be chemiotactic for the eosinophiles. Whether this be so or not, it is the experience of Ehrlich and Lazarus that the chemiotactic substances of bacteria, at any rate, act rather negatively than positively on the eosinophile cells.

Again the same authors state that the "direct cause of the majority of cases "of eosinophilia lies in the products resulting from a destruction of tissue." May it be that the digestion of the stroma of the glands which must apparently precede the sinus formation is the cause of the production of these chemiotactic substances? The physiological storehouse of the eosinophiles, they consider to be the bone-marrow, and they do not consider that these cells can originate locally in any organ or tissue or can be derived from the finely granular neutrophiles by transformation in the circulation, as was held by Muller and Rieder. Haemolymph glands, however, have been thought by Warthin and others to have a somewhat close connection with the bone-marrow, and it is not, therefore, unlikely that eosinophile cells might be locally manufactured in these glands. Nevertheless, no sign of any mitosis was observed in the eosinophile cells.

It is an interesting fact that both polymorpho-nuclear leucocytes and eosinophile cells were found in large numbers in the same glands. Ehrlich and Lazarus state that substances chemiotactic for the former are not so for the latter; *e.g.*, the products of the metabolism of bacteria are chemiotactic for the polymorpho-nuclear cells, which has been already noticed, they act negatively on the eosinophiles.

3. There is a definite fibrous tissue formation in these glands by which they become more or less sclerosed.

While this process is present in the cervical glands in later stages of the disease, it is most marked in the inguinal glands. In the thickening of the capsule, as well as in the intra-glandular sclerosis, the lymphocytes apparently take some part.

4. There is a marked change in the cellular contents of the gland.

In addition to the lymphocyte, both small and large, are found leucocytes of every variety, many of which are probably phagocytic. Of these the most remarkable is the giant poly- or mono-nuclear cell containing many red blood corpuscles. Mast cells are by no means uncommon. Ehrlich and Lazarus give the bone-marrow as their place of origin. They also state, however, that they may be derived from connective tissue cells, and are increased locally wherever abnormal nourishment of the connective tissue occurs, *e.g.*, in chronic diseases of the skin. Whether their origin is due, in this case, to an abnormal nourishment of the gland connective tissue, through hyperaemia, which passes on to sclerosis, or whether they are manufactured locally, the haemolymph gland taking on some of the functions of the marrow, their presence is equally interesting. They may, however, have come to the gland by blood-stream.

There seems to be a good reaction on the part of all the cells in the gland to some stimulus, possibly the product of the trypanosomes; and cell division is abnormally frequent.

It is not easy to correlate the stages of the pathological process in the glands with the clinical stages of the disease. Cases are divided clinically into three types: A, those with no symptoms; B, those with some symptoms; C, those with many symptoms.

The glands described in the first group were excised from a patient who would come under type A. Here, as might be expected, the absence of symptoms corresponds with glands that show the least departures from the normal. The patient, Tschomba, too, was at a very early stage of the disease, and in his case there was but little more abnormality in the glands than in the first group.

The remainder of the patients would come under types B and C. The cervical glands of the most advanced case did not show on the whole more departures from the normal than other cases, clinically less advanced. The inguinal glands were excised from an advanced case, and showed the most striking lesions. In each of the other cases some glands showed greater pathological changes than others, and parts of the same gland were very unequal in this respect.

PLATE VI.

Fig. 1.

Fig. 2.

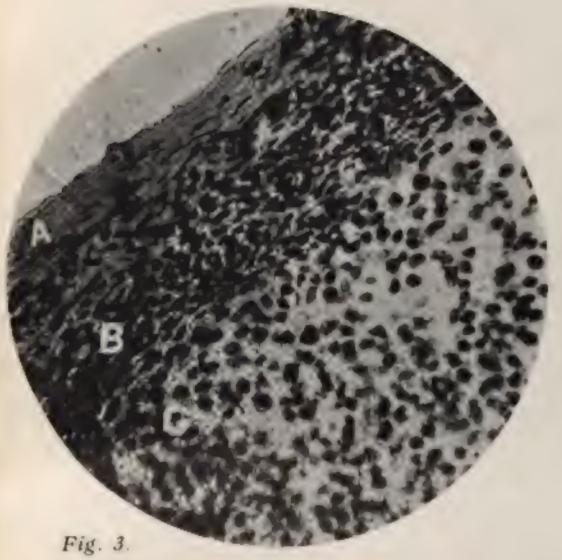

Fig. 3.

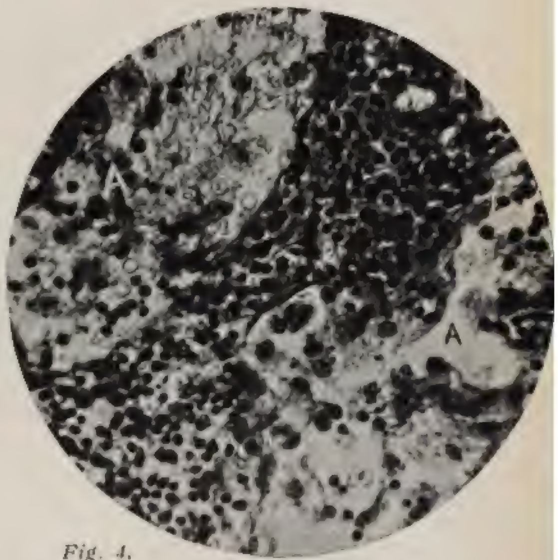

Fig. 4.

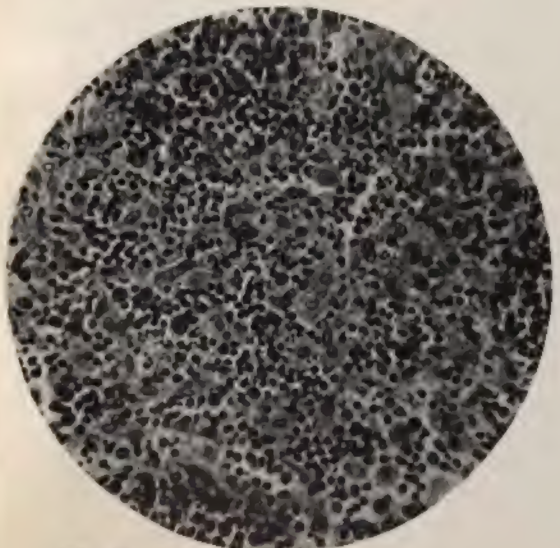

Fig. 5.

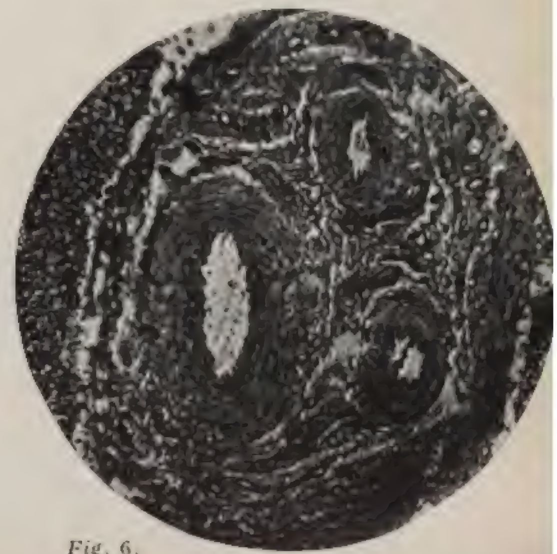

Fig. 6.

PLATE VII.

Fig. 7.

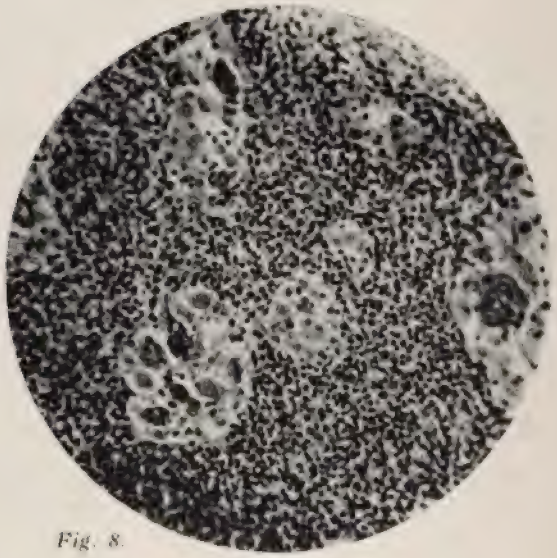

Fig. 8.

Fig. 9.

DESCRIPTION OF PLATES VI AND VII

Fig. 1.—Numerous germ centres in the cervical gland of an early case of human trypanosomiasis (page 70).

Fig. 2.—Illustrates the diffuse form of the "structural change" in the cervical gland of an early case (page 72).

Fig. 3.—Gland of an advanced case. A, capsule; B, zone of spindle cells; C, lymph tissue (page 75).

Fig. 4.—Gland of an advanced case. A, A, lymph sinuses containing red cells, etc., and bordered by endothelium (page 76).

Fig. 5.—Illustrates the presence of large numbers of polymorphonuclear leucocytes in the substance of lymph glands of an advanced case (page 79).

Fig. 6.—Thickened vessels at the hilum of a gland from a far-advanced case (page 79).

Fig. 7.—Marked sinus formation in the gland of a far-advanced case (page 79).

Figs. 8 and 9.—Sinuses of the gland illustrated in Fig 7, containing red cells, giant cells and phagocytes with engulfed erythrocytes (page 79).

CONCERNING CERTAIN PARASITIC PROTOZOA OBSERVED IN AFRICA

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Seventh Interim Report from the Expedition of the Liverpool School of Tropical Medicine to the Congo, 1903-04-05

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PART I

During Expeditions sent to the British Colony of the Gambia (1902-1903) and to the Congo Free State (1903-04-05) for the purpose of studying human trypanosomiasis and tropical sanitation, parasitic protozoa were frequently encountered.* Lack of time forbade an immediate study of organisms not directly connected with the main work of the expedition. Short notes were therefore made of the appearances in fresh preparations of such parasites, and dry films were preserved for future examination. The present paper is therefore based, in part, on fresh coverslip preparations, and, in part, on dry, stained films, examined after an interval of several months. It presents all our observations on parasitic protozoa, with the exception of those made on the spirochaetes of tick-fever and trypanosomes of man and on the pathogenic trypanosomes, of the *dimorphon* type, of animals. These latter parasites are treated of in other, past or future, publications from this school. The publication of these observations has been considerably delayed in the hope that

* For the routes followed by these expeditions and for the position of places mentioned in this report please refer to maps contained in Memoir XI, of this School, for the Gambia, and to Memoir XVIII or XXII for the Congo Free State.

an opportunity of completing them would be found: none has presented itself. Rather than put off their publication any longer it has been thought well to communicate the following notes in their present uncompleted state.

For convenience of reference, the parasites spoken of in this paper have been classified according to the host in which they were found. Parasites conforming to types on which widely-accepted generic or specific names have been conferred are classified under those names without question. The work of the regretted Schaudinn and his followers has revealed, however, unsuspected identities between supposedly distinct species and even genera of protozoa. We, therefore, believe that the greatest caution should be exercised in naming parasites whose life-cycle is not completely known; for this reason unidentified parasites mentioned in this paper, as a rule, are left unnamed. If, however, an unidentified parasite possesses very peculiar characteristics it may be desirable to give it a specific name for descriptive purposes. For this reason we have given names to some of the parasites described in this paper. It must, however, be understood that we intend these names to be purely for convenience of description and that we by no means wish to definitely adjudicate upon the systemic position of the parasites on which they are conferred.

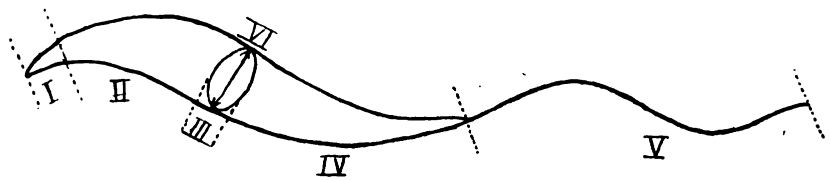

FIG. 1

For convenience of comparison the measurements of trypanosome-like forms are tabulated according to a formula we have used for some years (Lingard[1] has recently suggested a similar method). Five, and sometimes six, measurements are taken of each parasite in the manner indicated in the accompanying sketch (Fig. 1).

Occasionally the blepharoplast is placed so near to the posterior extremity of the parasite that the distance between them cannot be accurately measured. In such parasites Measurement II is taken from the posterior end of the parasite to the posterior border of the nucleus. In other parasites (see Plate IX) a considerable distance intervenes between the posterior end of the parasite and the blepharoplast; Measurement II is then taken from the centre of the blepharoplast to the posterior border of the nucleus, while Measurement I runs from the posterior extremity of the parasite to the centre of the blepharoplast. Measurement III runs from the posterior to the anterior border of the nucleus. Measurement IV is from the anterior border of the nucleus to the anterior extremity of the body of the parasite. Measurement V gives the length of the free flagellum. Measurement VI, usually taken at the level of the nucleus, represents the greatest width of the parasite *without* the undulating membrane.

It must be remembered that the bodies of trypanosomes are more or less amoeboid. Their shape varies, and these measurements are far from constant in members of the same species. They have, however, been found distinctly useful in the comparison of various trypanosomes.

LITERATURE

1. Lingard, 1906. Journal of Tropical Veterinary Science, No. I, pp. 5-14.

Mammals

Representatives of the following species were examined:—Man, chimpanzee, monkey—*Cercopitheci* of twelve different varieties, *Colobi* of three varieties, *Cyanocephalus*-, galago, civet (*Mandinia binotata*), mongoose (? *Herpestes gracilis*), jackal (*Canis anthus*), dog, hippopotamus, buffalo (*Bos nanus*), cattle, horses, donkeys, mule, sheep, goats, camels, antelopes (*Hippotragus equinus*, *Tragelaphus scriptus*, *Cervicapra arundinum*, *Cephalophus dorsalis*, *Bubalis senegalensis* and *jacksoni*-), wart hog (*Phagochaerus aethiopicus*), bat (five unidentified varieties), mole, shrew (*Crocidura sp*?), hare, rat (*Arvicanthus pumilio* and *abysinicus*, *Mus decumanus*), palm-rat, "cane rat," mice (*Mus musculus*), field mice (*sp*?), "chipmunk" (*sp*?), pangolin (*Manis tricuspis*).

MAN

Trichomonas vaginalis

Apparently the ordinary type of this parasite, with three flagella, was obtained from negro women suffering from "sleeping sickness" at Leopoldville.

Malaria

In the Gambia, as in the Congo Free State, considerable numbers of negroes, especially children, were examined for the purpose of determining the malarial indices of various localities. It was found that malarial parasites of the aestivo-autumnal, tertian and quartan types were present practically everywhere; they are mentioned in the order of their usual frequency. In one instance, however, a group of soldiers' children who had just come to Leopoldville from Lukonzolwa in the Southern portion of the Congo Free State were nearly all found to be infected with tertian parasites alone. Double infections with any two varieties of parasites were common.* The number of the aestivo-autumnal cases in whom crescents were seen frequently reached 20 %.

It was found that adult negroes, natives of localities where malaria was endemic, suffered from acute attacks of malarial fever more frequently than is generally taught. On several occasions during our stay in the Congo, negroes, over 20 years of age, with acute malaria presented themselves for treatment. We, therefore, consider it necessary to carefully examine the blood for malarial parasites in every case of fever in natives.

Spirochaetes

At Bumba two or three cases of a peculiar type of onychia were seen on the toes of children and adults. The process commenced by an ulceration beneath the fore-part of the nail; it gradually spread backwards until the nail died, dropped off, and left exposed a granular, ulcerated surface covered by an easily-crushed, caseous-like, white membrane. Unfortunately, fresh preparations of this membrane were not observed; but smears, fixed in alcohol and stained by a modification of Romanowsky's method, were examined. They were

* A double infection with *Spirochaeta duttoni* and malaria was seen on two occasions: in a European and in an African.

found to contain, besides scattered leucocytes and debris, bacteria and spirochaete-like organisms.

The bacteria all decolorised by Gram's method of staining with the exception of a very few scattered cocci. They comprised various bacteria and a leptothrix.

The spirochaete-like organisms varied very considerably in form. A constant type (Plate VIII, Figs. 1, 2, 3, 4) possessed a central portion staining darkly and, usually, uniformly; rarely, small unstained areas of inconstant position were present (Figs. 8 and 9); in well-stained specimens a lightly-stained "flagellum" measuring about $1 \cdot 5\,\mu$ in length or more could be detected at either end of the parasite (Figs. 1, 2, 5, 8, 10, 14, 15). The whole parasite measured about $10\,\mu$ in length and about $\cdot 25\,\mu$ to $\cdot 3\,\mu$ in breadth. It is impossible to definitely say whether flagella actually occur or whether the appearances simulating them are due to the prolongations of the periplastic "sheath" of the organism. We incline to the latter view since, at their junction, the width of the body of the organism and the "flagellum" are usually the same; in addition, in some cases, the "flagella" are seen to stain in the same way as do areas of the parasite from which chromatophilic material is absent. Whether free "flagella" can be detected or no, the ends of the organism are always finely pointed. The number of its waves varies, but there are usually from $2\frac{1}{2}$ to 5; they may be either abrupt and closely-coiled, or sweeping (Figs. 1 and 3). The length of organisms of this general appearance may vary considerably (Figs. 8, 9, 10); apparently single parasites measuring $21 \cdot 6\,\mu$ occur. Their breadth is, as a rule, uniform, but forms (Figs. 6 and 7) are seen in which there are decided thickenings.

Organisms whose inner, darkly-staining portion had broken up into numerous purple granules were frequent (Figs. 11, 12).* In some parasites the granules were fewer in number, and correspondingly increased in size (Fig. 13). In every case the contour of the spirochaetes was preserved by the lightly-stained periplast.

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* The drawings accompanying this paper, and in particular those of the granular parasites, should be compared with the illustrations of other blood spirochaetes given by Novy,[2] Prowazek[3] and Stephens,[1] and with the description of *Spirochaeta duttoni* on pages 24 and 46 of this volume. Lack of material prevented a careful study of the arrangement of the granules, but occasionally they were seen to be placed in pairs arranged longitudinally and more or less regularly (5).

The granular, like the uniformly-staining, forms varied considerably in length (Figs. 11, 12). Both types occurred either singly, in pairs or in triads joined by their extremities (Figs. 14, 15, 19). Rarely, either granular or uniformly-staining parasites ended at one extremity in a knob composed of a single purple granule (Figs. 18, 19) or of a lightly-staining ground substance in which lay several (four to five) chromatophilic granules (Figs. 16, 17).

The striking morphological resemblances between the forms illustrated in this paper and the variations in the shape of blood spirochaetes, described by various authors (1, 2, 3), suggests that all of these organisms may be of a similar nature. We are inclined to believe that the blood spirochaetes are protozoa, and, therefore, the present parasite is described under that heading.[4] We are, of course, aware that similar organisms have been seen in other foul sores, and we do not assert that this parasite is a specific cause of the perionychia in which it was observed.

LITERATURE

1. Stephens, 1906. "A Note on the structure of *Spirochaeta duttoni*." The Lancet, August 18th.

2. Novy and Knapp, 1906. "Studies on *Spirillum obermeieri* and related organisms." Journal of Infectious Diseases, Vol. III, No. 3, May, pp. 291-393.

3. Prowazek, 1906. "Morphologische und entwicklungsgeschichtliche Untersuchungen über Hühnerspirochaeten." Arbeiten aus dem Kaiserlichen Gesundheitsamte. XXIII, Bd., zweites Heft, Berlin.

4. Blanchard, 1906. "Spirilles, spirochaetes et autres microorganismes à corps spiralé." Archives de Parasitologie. Tome X, No. 2. May 1, 1906.

5. Perrin, W. S., 1905. "A Preliminary communication on the life-history of *Trypanosoma balbianii*." Proceedings of the Royal Society, London, Series B, Vol. 76, p. 368-375.

MONKEYS

Malaria

Malarial parasites of a type similar to that described by Kossel[1] and Luhe[2] were frequently seen in monkeys (*Cercopitheci*) caught at Kasongo. Professor Ronald Ross has kindly undertaken the study of our material, and will shortly publish a description of the parasites as they are seen in the blood stream.

LITERATURE

1. Kossel, 1899. "Ueber einen malariaähnlichen Blutparasiten bei Affen. Zeitschrift für Hygiene und Infektionskrankheiten." Band XXXII, p. 25.

2. Luhe, 1906. "In Mense, Handbuch der Tropenkrankheiten." Band III, p. 223.

A Trypanosome

At Kasongo, from January to April, 1905, trypanosomes were seen in the blood of two newly-caught *Cercopithecus schmidti*; these were the only monkeys infected amongst some thirty *Cercopitheci* caught at the same time and place. About forty *Cercopitheci schmidti* in all were examined at various places in the Congo Free State; only these two were naturally infected with trypanosomes. This trypanosome is, therefore, a comparatively rare parasite.* The trypanosomes were scanty, and were rarely seen, although the blood of the infected animals was frequently examined both by centrifugalisation and by ordinary coverslip preparations. In one animal the parasites were seen once by the examination of coverslips and three times by centrifugalising. In the other monkey, they were found once in coverslips and once by centrifugalising. Films of blood for staining were made when the parasites were known to be present. Fifty-four of them (approximately 540 square centimetres of stained films) have been carefully examined, but unfortunately no trypanosome was found. We are, therefore, only able to describe this parasite from its appearance in fresh preparations.

It is a very large parasite, whose body, without flagellum or undulating membrane, measures approximately 25 μ or more in length by 2·5 μ in breadth. Its movements are vigorous, but there is little progressive motion; particularly striking are the rapid, sweeping movements of the very wide and much-folded undulating membrane. The protoplasm of the parasite is not very granular. The blepharoplast can be distinguished as a very highly refractile spot placed at a point distant about a quarter the length of the body of the parasite from its slender posterior extremity. Quite close to the blepharoplast, and anterior to it, is the rather undersized nucleus. The free flagellum is long and, as nearly as could be estimated, forms about a third or a quarter of the total length of the parasite.

One of the monkeys infected with this parasite had also malaria of the type indicated above. Both were used in experiments in

* Since research work on trypanosomes and spirochaetes has been commenced at the Runcorn Research Laboratories, some 165 monkeys have been used for various experiments necessitating blood examinations; the majority of them were from Africa, the remainder from Asia. Spontaneous infection with trypanosomes was seen in none of them.

connection with "tick-fever" in which numbers of *Ornithodoros moubata* were allowed to feed upon them. Both animals were under observations for a considerable period, five and two months. No symptoms were observed which could be attributed to the trypanosomes, save perhaps a slight rise in temperature. Trypanosomes were seen both by day and night. No marked rise of temperature accompanied their presence in the peripheral blood. At the autopsies on these monkeys (death due to other causes) trypanosomes were not seen, nor were there any lesions which could be considered to be due to them. Our description of this parasite agrees excellently with the characters of a trypanosome described by Kudicke. His parasite was observed in the blood of a *Cercopithecus sp?* (German, "meerkatze") in German East Africa.* His monkey had been inoculated with the blood of a (?) "sleeping sickness" patient. The appearance of *Trypanosoma gambiense* in the blood did not follow the inoculation, but this unidentified parasite was seen on two occasions. Kudicke seems inclined to believe that it came from the (?) "sleeping sickness" patient, but discusses the possibility of there having been a natural infection in the monkey, and in the latter event he suggests that the parasite may be *Trypanosoma theileri* or possibly a new species. For the following reasons, we believe that we have seen the same trypanosome as Kudicke: the parasites occurred in monkeys of closely related, or perhaps the same, species collected in not widely-separated localities; in each instance the parasites were scanty, rarely seen, and but feebly pathogenic; both observers give a similar description of the morphology of the parasite. This is the first trypanosome to be observed in naturally infected monkeys. Its characters seem to be constant and, as Kudicke states, it somewhat resembles *Trypanosoma theileri*, but, as he also mentions, only cattle are known to be susceptible to *Trypanosoma theileri*. From a consideration of all the facts, we are inclined to believe that we are dealing with a hitherto unobserved parasite.

ANTELOPES

Trypanosomes more or less resembling *Trypanosoma dimorphon* in appearance and animal reaction have been seen in antelopes and

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* Kudicke, 1906. "Centralblatt für Bakteriologie." 1 Abt. Orig., Bd. XLI, Heft, April 12th.

cattle all along the Congo from Leopoldville to Kasongo. Both "stumpy" and "long" forms [1, 2] have been seen in these animals. A forthcoming paper fully considers the subject of cattle trypanosomiasis in the Congo Free State.

LITERATURE

1. Dutton and Todd, 1903. Memoir XI, Liverpool School of Tropical Medicine.

2. Martin, 1906. "Comptes rendus de la Société de Biologie." Tome LXI, p. 77.

Trypanosoma theileri

Although no disease resembling the "Gall-sickness," caused by *Trypanosoma theileri* in South Africa, has been seen among cattle in the Congo Free State, a trypanosome, morphologically resembling that parasite, was found in small numbers in the blood of an antelope (an old male *Tragelaphus scriptus*) killed at Kasongo in February, 1905.

Rabbits and guinea-pigs were inoculated with large amounts of blood from this antelope but never became infected.

In fresh preparations the trypanosome displayed the usual active movement of *Trypanosoma theileri*.[1] The following observations have been made on its appearance in stained preparations. It is to be regretted that our scanty material prevented as full a study of this parasite as might be desired.

Two types of trypanosomes appeared in our preparations; the first, a wide form, had a poorly-developed undulating membrane (width ·75 μ), its rounded centrosome was placed just posterior to the nucleus and its posterior extremity was slender and sharp pointed (Plate IX); the second, a slender form, possessed a wider undulating membrane (width 2·5 μ), and its rounded centrosome was near the blunted posterior extremity.

The average measurement of these two types are indicated in the following table:—

		Wide Form		Slender Form
Measurement I	...	15-31 μ	...	6 μ
" II	...	3 μ	...	25 μ
" III	...	4·5 μ	...	3-4·5 μ
" IV	...	21-42 μ	...	33 49·5 μ
" V	...	9 μ	...	*
" VI	...	6·75-7·5 μ	...	4·5 μ
Total body length without flagellum ...	...	43·5-79·5 μ	...	72-87 μ

In the wide form, the oval nucleus is placed transversely, just posterior to the middle of the parasite and occupies the entire width of its body. The endoplasm is coarsely or finely granular, and at the posterior extremity is retracted (for 4 μ) within the sheath of the clearly-visible, pink-staining periplast. Its striations are a striking feature of this type. They are of two kinds: the one is superficial, wide, curved, spiral and dark-pink in colour; the other is deep, narrow, straight, longitudinal and light-coloured. The narrow, longitudinal, apparently endoplastic (?) striations were particularly well seen in the anterior portion of one of our specimens from which the periplast seemed to have been partially removed (probably by violence in preparing the film); near the nucleus fifteen such striations could be counted, while at the anterior extremity there were but four (see Plate IX). The spiral striations were better seen in the posterior half of the body of the parasite, but they were also present in the anterior half, and there, by careful focussing, both longitudinal and spiral striations could be successively seen.

In the slender form the rounded nucleus is placed at the middle of the parasite, and occupies the whole width of its body. The protoplasm of this type is finely-granular, denser and more deeply-staining than in the wide form. Indications of a longitudinal striation can occasionally be detected.

Divisional forms of neither type were seen.

From this rapid description it is seen that this parasite conforms to the general description of *Trypanosoma theileri*.[1, 2, 3] It differs in that its dimensions are greater than those given for *Trypanosoma theileri*, and that the posterior extremity of the slender form is much blunted. These differences are but slight, and when it is remembered that *Trypanosoma theileri* has been comparatively little studied, we

* A perfect flagellum was present in none of the seven, more or less imperfect, specimens of this type seen in our preparations.

feel justified in assuming for the present that *natural infection of antelopes with Trypanosoma theileri occurs in Africa as far north as Kasongo.*

LITERATURE

1. Luhs, 1906. "Trypanosoma theileri in transkaukasien." Archives de Parasitologie, Tome X, No. 2, p. 175.
2. Laveran and Mesnil, 1904. "Trypanosomes et trypanosomiasis." Paris, Masson et Cie.
3. Mense, 1906. "Handbuch der Tropenkrankheiten." Band III, p. 134.

BATS

The blood of many bats of at least five different varieties was examined. The only parasites found were in three small insectivorous bats caught at Bathurst, Gambia. All three were infected with malarial parasites; one of them in addition had very scanty "spirochaetes" (?) The latter parasite was very small and very active. It was seen only in fresh preparations, and therefore it is impossible to be quite certain of its exact nature. The endoglobular parasites occurred as "rings," intermediate forms and gametes. The young ring forms were very numerous. Double infections of a single cell were frequent. The older parasites completely filled the red cell and were always heavily pigmented. The pigment occurred in short, dark, golden-brown rods with bluntly-rounded ends. The chromatin appeared as small dense, irregular granules which were distributed throughout the parasite; in some as many as 10 such granules were counted. Schizonts and flagellating mikrogametocytes were not seen. This parasite seems most to resemble the quartan-like haemosporidium described by Dionisi.[1]

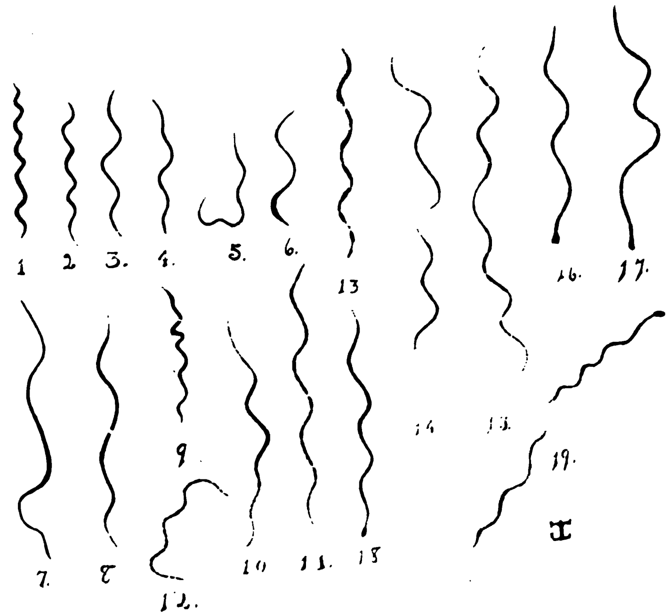
LITERATURE

1. Dionisi, 1899. Ueber endoglobuläre Parasiten bei den Fledermausen; Naturlehre des Menschen und der Thiere. Band XVI, p. 533.
2. Kisskalt. Blutparasiten bei Fledermausen. Centralblatt fur Bakteriologie, I Origin. T. XL, 16th Dec., 1905. Bull. Past. T. IV, p. 255.

RATS

Wild rats (? *Mus decumanus*) caught in St. Louis, Senegal, and at Bathurst, Gambia, harboured *Trypanosoma lewisi.* This parasite was seen in the Congo Free State at Boma, Matadi, Leopoldville and Kasongo. The infected rats belonged to the following species, *Mus decumanus*, *Arvicanthus abysinicus* and *Arvicanthus pumilio.* The parasites were also seen in one other unidentified rat. In no instance was any unusual appearance observed in the parasites.

ATE VIII. (page 38).



Spirochaeta duttoni × 2000.

Fig. 20.
Spirochaeta laverani × 2000.
(Page 55).

× 4000

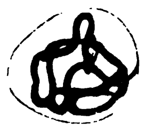


Fig. 21.
Encysted form of spirochaeta duttoni. (Page 47).

PLATE IX.

Trypanosoma theileri.

× 4000

ATTEMPTS TO CULTIVATE *SPIROCHAETA DUTTONI*

ATTEMPTS TO CULTIVATE *SPIROCHAETA DUTTONI**

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In attempting to cultivate *Spirochaeta duttoni* on artificial media three important questions must be considered:—

A. The medium to be employed;

B. The optimum temperature;

C. The stage of the disease at which the infected blood should be taken and the greater or lesser virulence of the spirochaetes.

A. The Medium to be Employed

Attempts were made with defibrinated horse's blood 1 part, agar 1 part; also with defibrinated horse's blood 3 parts, agar 2 parts; the results obtained were not very satisfactory, the agar was discarded and the experiments continued with defibrinated horse's blood and defibrinated rabbit's blood. These media were the most successful; in defibrinated horse's blood motility and virulence for rats were found to exist on the 27th day, and in rabbit's blood on the 25th day. In the defibrinated rabbit's blood there was apparent multiplication of the spirochaetes during the early days of cultivation, none the less attempts to subculture were unsuccessful (Charts A and B). Other

* The following experiments were made between February 22nd and April 11th, 1906.

media tried were hens' eggs and inspissated horse's blood serum, on these the results were entirely negative except in the case of one tube of blood serum which contained water of condensation; here the spirochaetes remained motile for three days. Since it was always in the more fluid media that the spirochaetes continued to live, further experiments were performed with "Lemco" broth.

Water	... ...	to 1,000 ccm.
Peptone	... ...	20 grammes.
"Lemco"	... ...	7·5 grammes.

Neutralized to litmus.

As controls normal saline and distilled water were inoculated In "Lemco" broth motility was lost earlier than in the defibrinated blood tubes, and virulence to rats had almost ceased to exist by the 18th day. In normal saline the spirochaetes remained motile for two days, after this they could no longer be observed either in fresh or stained specimens. The distilled water, though inoculated with heavily infected blood, failed to show the presence of spirochaetes either on the next or subsequent days.

It seems, then, justifiable to conclude that the defibrinated blood of rabbits or horses is favourable to the continued existence of *Spirochaeta duttoni in vitro*. Whether multiplication takes place is doubtful; in these experiments it was not sufficiently free to enable subcultures to be made. There are, at least, two explanations of this, one that the subcultures were not made often enough or were not made at the right temperature; a second that an intermediate stage occurs in the life history of this spirochaete, and that the media used did not supply the necessary nourishment for that stage. In this connection the morphological changes observed may be of importance.

Briefly these resembled the appearances observed by Breinl and Kinghorn, and described on page 24 of this report. In the "cultures" the spirochaetes occasionally appeared to be thinner than normal and frequently stained irregularly. Bulbar swellings were seen towards the central portions of many of the spirochaetes; others had these rounded masses attached to one side of the body. In the stained specimens the parasites were often found to be disposed in irregularly-tangled masses, and lying between the individual spirochaetes large numbers of small, round or oval, deeply-stained bodies were observed.

B. Optimum Temperature

It was early observed that at 37° C. the spirochaetes rapidly lost their form and motility. The later experiments were therefore performed either at 22° C. or at room temperature. The room temperature was occasionally as low as 12° C., sometimes as high as 24° C., the average was about 15° C.

C. The Stage of the Disease at which the Infected Blood should be taken and the Virulence of the Spirochaetes

Table I indicates, briefly, particulars of the most successful attempts at cultivation. As is seen the blood was generally taken at the height of a highly virulent first attack. This is not essential, since the infected blood used to inoculate the defibrinated-horse-blood tubes was taken when spirochaetes could not be found in it by the ordinary method of examination;* the parasites, however, had been present on the previous day and were again seen on the day following.

TABLE I

Medium	Date	Temperature	Stage of disease	Virulence of attack	Length of virulence in medium	Duration of motility in medium
Defibrinated rabbit blood	11.3.06	Room	Middle, 1st attack	Great	At least 4 days	12 days
Ditto	24.3.06	"	" " "	"	16 days	16 days
Ditto	30.3.06	"	" " "	"	25 days	25 days
Defibrinated horse blood	11.4.06	"	Interval (?) between two attacks, parasites not seen	Mild	27 days	27 days
"Lemco" broth	22.3.06	"	Middle, 1st attack	"	18th day	18th day

Detailed Account of Experiments

1. Medium: { Defibrinated horse's blood... ... . / Agar... ... ... } equal parts.

FEBRUARY 2ND, 1906.—Two tubes kept at 22° C. received each 4 to 6 drops of blood containing 6 spirochaetes to a field from a rat (RW1) just over the height of the attack; the number of parasites present was declining. All the tubes remained uninfected (30 daily examinations).

* That is, thick, de-haemaglobinised blood-films, were stained by a modification of Romanowsky's method and examined with a Zeiss $\frac{1}{12}$ oil-immersion objective.[1]

FEBRUARY 8TH, 1906.—Four tubes kept at 22° C. were inoculated with rat's (RW3) blood containing very few spirochaetes (commencement of attack). The parasites remained motile for only three days, but were found in stained preparations for 21 days.

FEBRUARY 20TH, 1906.—Four tubes kept at 37° C. were inoculated with rat's (RW4) blood containing innumerable spirochaetes (height of attack), examined for 25 days, but remained uninfected.

2. Medium: { Defibrinated horse's blood ... ... 3 parts.
Agar ... ... 2 parts.

FEBRUARY 2ND, 1906.—Four tubes kept at 22° C. were inoculated with rat's blood, (RW1, see above), examined for 30 days, but remained uninfected.

FEBRUARY 8TH, 1906.—Four tubes kept at 22° C. were inoculated with rat's blood (RW3, see above). On the following day motility was found, none afterwards. In stained specimens spirochaetes were seen for 21 days. On the 20th day subcultures were made on defibrinated horse's blood and agar equal parts without result.

FEBRUARY 20TH, 1906.—Four tubes inoculated from RW4 (see above), incubated at 37° C.; two were uniformly negative for 25 days, of the remaining two, one showed irregularly-stained spirochaetes on the 7th day, afterwards negative, the other showed irregularly-stained spirochaetes on the 25th day, afterwards negative.

FEBRUARY 23RD, 1906.—Six tubes kept at 37° C. were inoculated with blood containing innumerable spirochaetes from RW5; this rat was at the height of the first attack. One tube was uniformly negative, one showed spirochaetes up to 12th day, one to 14th day, two to 20th day, and one to the 33rd day; from this tube one attempt was made on the 28th day to infect a rat (RW14), the result was negative. In all the tubes motility was rapidly lost, the stained specimens showed irregular coloration and the spirochaetes had attached to, or near them, numerous darkly-stained dots of various sizes.

MARCH 8TH, 1906.—Two tubes, kept at room temperature, were inoculated with blood containing numerous spirochaetes from a rat (RW8) at the height of the first attack; there was no growth.

MARCH 11TH, 1906.—Three tubes, kept at room temperature, were inoculated with blood containing innumerable spirochaetes from RW10, a rat at the height of the first attack. Irregularly-stained spirochaetes were seen for three days, afterwards examinations were uniformly negative.

3. Medium: Defibrinated rabbit blood.

MARCH 11TH, 1906.—Eight tubes, kept at room temperature, were inoculated with blood containing innumerable spirochaetes from a rat (RW10, see above). The parasites apparently multiplied for 9 days, and in one tube (4) motility was seen on the 12th day. Spirochaetes were found in stained preparations for 17 days. On the 3rd day two tubes of defibrinated rabbit's blood were subinoculated from tube 4, and incubated at 22° C; on the 4th day these tubes were positive, one of them was used to inoculate a rat which became positive four days later and reached the height of its attack (30 to 60 per field) in seven days from date of inoculation, the other tube was kept and examined with uniformly negative result for eight days. On the 5th day (March 16th) subcultures were made from tube 4 on defibrinated rabbit's blood, these were kept at room temperature and were negative for 20 days.

Result.—Motility 12 days.
Virulence for rat, at least, 4 days.
Subcultures on defibrinated rabbit blood at room temperature and 22° C. failed.

MARCH 24TH, 1906.—Three tubes, kept at room temperature, were inoculated with blood containing innumerable spirochaetes from a rat (RW13) at the height of the first attack.

The history of these tubes is tabulated below (see Chart A). It is seen that—

(a) Motility was present for 16 days.

(b) Virulence for rat continued for 16 days.

(c) Four attempts at subcultivation, all at room temperature, were unsuccessful.

I.—7th day, "Lemco" broth	... ...	result negative.
II.—10th day, defibrinated rabbit blood	...	" "
III.—12th day { defibrinated rabbit blood, 1 part		" "
{ "Lemco" broth, 1 part	...	" "
IV.—14th day, defibrinated horse's blood	...	" "

MARCH 30TH, 1906.—Five tubes, kept at room temperature, were inoculated with blood containing innumerable spirochaetes from (RW16) a rat at the crisis of the first attack.

The history of these tubes is tabulated below (see Chart B). It is seen that there was—

(a) Motility in one tube for 21 days (used up for animal inoculation). Motility in two tubes for 25 days (one used up for animal inoculation, the other became contaminated).

(b) Spirochaetes seen in stained preparations for 31 days.

(c) Virulence in one tube for, at least, 21 days, and in another for 25 days.

(d) Subcultures in the 8th day on defibrinated horse's blood, at room temperature were a failure. Subcultures on the 24th day on defibrinated rabbit's blood, at room temperature, also failed.

4. Medium: Defibrinated horse's blood.

APRIL 7TH, 1906.—Three tubes, kept at room temperature, were inoculated with blood containing numerous spirochaetes from a rat (1,082B) at the height of the first attack.

The tubes remained negative for 12 days and were then discarded.

APRIL 11TH.—Three tubes, kept at room temperature, were inoculated with blood from rat 1,082C. No spirochaetes were seen although they were present on April 10th and 12th. The history of these tubes is tabulated below (Chart C). It will be seen that tube 1 became contaminated on the eighth day. Tube 2 showed motility on the 14th day, and the presence of spirochaetes on the 27th day when they were very few, and faintly and irregularly stained; the contents of this tube, 10 ccm., were then inoculated intraperitoneally into a rat, 1,143A (Table II), which showed parasites in its blood on the day following and passed through a typical attack with a relapse.[1, 2] Tube 3 showed motility on the 27th day, in stained preparations the spirochaetes were seen to be few in number and faintly coloured; on May 8th, 5 ccm. were inoculated intraperitoneally into a rat, 1,143B (Table II). Parasites appeared in its blood 3 days later, and the animal passed through an ordinary attack.

In both these tubes virulence was thus retained for 27 days. It is possible that motility was present at the time of inoculation in tube 2, but that it was not observed. The more marked attack in rat 1,143A was probably due to the larger dose inoculated.

Attempts to subcultivate from these tubes were made as follows:—

3rd day on defibrinated horse's blood, room temperature.—Result negative.

14th day on defibrinated horse's blood, room temperature.—Result negative.

14th day on defibrinated horse's blood, 22° C.—Very occasional spirochaetes seen for 4 days.

TABLE II

Days after inoculation	Defibrinated Horse's Blood		"Lemco" Broth	
	Rat 1143A	Rat 1143B	Rat R.W. 18	Rat R.W. 22
1st day	Negative	Negative	Negative	Negative
2nd "	1 to 5 fields	Negative	Negative	Negative
3rd "	20-30 to a field	1 to 5 fields	Negative	Negative
4th "	very numerous	1-3 to a field	Negative	1-3 to 15 fields
5th "	1 to 20 fields	1 to 5 fields	2 to a film	1 to 80 fields
6th "	Negative	Negative	1 to 60 fields	Negative
7th "	Negative	1 to 10 fields	1 to 20 fields	Negative
8th "	3-7 to a field	Negative	1-6 to a field	Negative
9th "	12-15 to a field	1 to 10 fields	Negative	Negative
10th "	20-30 to a field	1 to 2 fields, killed	Negative	Negative
11th "	18-30 to a field, killed	...	1 to 50 fields	Negative
...	...	...	Negative	Negative

5. Medium: "Lemco" broth.

MARCH 22ND, 1906.—Six tubes kept at room temperature, were inoculated with blood containing 30 spirochaetes to a field from RW11, a rat at the height of a comparatively mild attack. There was no apparent increase in numbers, but motility was found in tubes 1, 2, 3 and 4 on the 8th day, and in tube 2 on the 18th day. Tube 3 showed irregularly stained spirochaetes on the 27th day, and tube 4 on the 30th day. Tube 3 was inoculated intraperitoneally into a rat (RW18, see Table II) on the 8th day, parasites appeared in its blood in 4 days, and the animal went through an ordinary attack. Tube 2, still showing very slight motility, was inoculated intraperitoneally into a rat (RW22, see Table II) on the 18th day. Parasites appeared in its blood on the 4th day, remained for 2 days, then disappeared for good.

It is thus seen that in 8 days virulence had markedly diminished, though still producing infection, and in 18 days had almost entirely disappeared. As is indicated in Table II, the infection produced in rats by the injection of cultures of spirochaetes in "Lemco" broth seems less severe than that produced by cultures in defibrinated horse's blood. Subcultures were made in "Lemco" broth tubes on the 8th day and kept at room temperature; result negative.

6. Medium: Hens' eggs.

MARCH 5TH, 1906.—Six hens' eggs incubated at 22° C. were inoculated with blood showing 30 spirochaetes to a field from a rat (RW7) at the height of a mild attack. Fresh eggs were used, surface sterilised, shell pierced, infected blood injected and opening painted over with collodion. An egg was opened and examined at the end of each week for three weeks, the blood was found clotted and localised. No change had taken place in the egg and no spirochaetes could be found.

7. Medium: Solidified horse's blood serum.

On MARCH 27TH, 1906, six tubes were inoculated and kept at room temperature. Of these one contained water of condensation, and in this tube motility was observed for three days. In the remainder motility was rapidly lost, and the parasites appeared in stained preparations in small irregularly-stained groups of four to eight; there were a large number of darkly-stained dots attached to and also free from the spirochaetes.

8. Medium: Normal saline.

APRIL 2ND, 1906.—Three tubes, kept at room temperature, were inoculated with blood containing innumerable spirochaetes from RW17, a rat at the height of the first attack. The spirochaetes remained motile for two days; all subsequent examinations were negative.

9. Medium: Distilled water.

On APRIL 2ND, 1906, three tubes were inoculated from RW17 (see above) and kept at room temperature. The following day no spirochaetes could be seen either in fresh or stained specimens, the tubes remained negative for several days after which the examinations were discontinued.

We regret that stress of other work has prevented us from following out this investigation as closely as we could have wished. From our observations, however, we feel justified in concluding that:—

For the continued existence of *Spirochaeta duttoni in vitro*, (*a*) **defibrinated blood is the most favourable medium we have employed**; (*b*) **room temperature is, in our experience, the best**; and (*c*) **the period of the attack at which the spirochaete-containing blood is taken has little influence on the extracorporeal viability of the parasites.**

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CHART A

RAT, R.W. 13 (24.3.06)

	Tube 1				Tube 2		Tube 3		
1st day	Very motile				Very motile		Very motile		
2nd „	Very motile				Very motile		Very motile		
3rd „	Stain well				Stain well, very numerous		Stain well, up to 10 per field		
4th „	Motile				Motile		Very motile		
5th „	Very motile						Motile		
6th „	Very motile				Few motile				
7th „	Very motile		RAT. R.W. 19, inoculated 2 c.c.	Subculture: 'Lemco' broth, Room temp., Negative for 9 days					
9th „			2–3 per field				Very motile		
10th „	Slightly motile	Subculture: Defibrinated Rabbit blood, Room temp., Negative for 5 days	Very numerous			Subculture: Defibrinated rabbit blood, room temp., result negative	Few motile	Subculture: Def. rabbit blood, Room temp., Result negative	
12th „	Motile, few		2–6 per field			Subculture: 'Lemco' broth, Def. rabbit blood } equal parts, Room temp., result negative	Very motile, few		
14th „			1–10 per field				Motile, stain well 1 to 5 or 6 fields	Subculture: Def. horse's blood, Room temp., Result negative	
16th „	1–8 fields, Stain well, No motility.				1–20 fields, well stained		Very slightly motile		RAT, R.W. 21, inoculated, 2 c.c.
18th „	1–30 fields, Poorly stained, Medium dried up				Few freshly stained, Fresh negative		Few faintly stained		Negative
19th „					Medium dried up		Medium dried up		Negative
20th „									1–3 in 30 fields
21st „									1 in 25 fields 1 in 2 fields
22nd „									Negative
24th „									Negative
26th „									Negative
28th „									Negative

RAT. R.W. 16 (30.4.06)

30.3.06	Tube 1	Tube 1: Subculture	Tube 2	Tube 3	Tube 3: Rat, R.W. 24	Tube 4	Tube 4: Mouse	Tube 5	Tube 5: Subculture
1st day ...	Very motile								
4th ,, ...	Very motile, few		Very motile, numerous	Very motile, numerous ...					
6th ,, ...	Very motile		Motile, few ...	... ...		Few, very motile			
8th ,, ...	Motile, few ...		Negative						
10th ,, ...	Stain well, ... 1–4 per field	Subculture: Defibrinated horse's blood, Room temperature, negative to 25th day	1–2 per field, well stained	... ...		Very motile, 2–6 per field			
11th ,, ...	... ...		... ...	Irregular staining, numerous		... ...		Stained 2–8 per field	
12th ,, ...	Few, stain badly		Stained 1 per field	2–10 per field		Fresh negative, stained, 3–12 per field			
13th ,, ...	... ...		Fresh, few non-motile						
19th ,, ...	Very few, stain badly		Very few, irregularly stained	... ...		Slightly motile, stained 2–8 per field			
21st ,, ...	1–50 fields, fresh negative		Contaminated ...	1–12 per field, very motile ...		Very motile, 3–1 field	MOUSE inoculated	Very motile	
22nd ,, ...	... ...		... ...	... ...		...	1–30 fields		
23rd ,, ...	... ...		... ...	Fresh negative		...	1–5 per field		
24th ,, ...	Stained 1–60 fields		... ...	Very motile, numerous ...		...	10–20 per field	Very motile	Subculture: Defibrinated rabbit blood, room temp.
25th ,, ...	... ...		... ...	Very motile	RAT, R.W. 24, inoculated	... ...	Very numerous	Very motile	sp. seen
26th ,, ...	1–30 fields, stained		... ...	...	Negative ...	...	Used for rats, very virulent	No motility stained 1–4 fields	Contaminated
27th ,, ...	1–40 fields		... ...	...	2 spir. in film	.. ..		Contaminated	
28th ,, ...	1–30 fields, fresh negative		... ...	...	3–1 field (rat dead)				
29th ,, ...	2 seen								
30th ,, ...	1–20 fields (medium very thick)								
31st ,, ...	1–30 fields								
32nd ,, ...	(Medium dried up)								

CHART C

RAT, R. 1082 C.

11.4.06	Tube 1	Tube 1 — Subculture: Defibrinated horse's blood at Room temperature	Tube 2	Tube 2 — Subculture: Defibrinated horse's blood at 22° C.		Tube 2 — Subculture: Defibrinated horse's blood at Room temperature		Tube 3
1st day ...	Very motile ...	...	Non-motile ...	...	...	...	...	1–30 fields
6th „ ...	Very motile	...	Few, irregularly stained ...	...	...	...	...	Abundant, well stained
7th „ ...	Very motile ...	Negative ...	Very motile ...	...	...	...	...	Very motile, few in number
8th „ ...	Contaminated	Negative ...	Well stained, 1–20 fields ...	...	...	...	...	Well stained
9th „ ...	...	Contaminated	1–10 fields ...	...	...	...	...	1–6 to 8 fields
12th „ ...	...	...	1–15 fields ...	...	...	...	...	1–10 fields
13th „ ...	...	...	Non-motile ...	...	...	...	...	Slightly motile
14th „ ...	...	...	Motile ...	...				„ „
16th „ ...	...	...	Non-motile, 1–8 fields ...	Negative	1–30 fields, non-motile	Negative	Negative	1–8 fields
17th „ ...	...	...	1–5 fields, several groups 10–15	2 sp. seen	1–80 fields	Negative	Negative	1–8 per field, numerous groups
18th „ ...	...	...	1–3 per field „ „	Negative	2 sp. seen	Negative	Negative	1–2 to 3 fields „ „
19th „ ...	...	...	1–5 to 10 fields „ „ „	Negative	Negative	Negative	Negative	1–5 to 10 fields
27th „ ...	...	...	Few, faintly and irregularly stained	Negative	Negative	Negative	Negative	Few, faintly stained, motile
28th „ ...	...	...	... RAT, 1143 A, inoculated	...	...	...	...	RAT, 1143 B, inoculated
29th „ ...	...	...	...	...	...	...	...	...
30th „ ...	...	...	... Positive	...	...	...	...	Positive

ATTEMPTS TO TRANSMIT SPIROCHAETES BY THE BITES OF *CIMEX LECTULARIUS*

ATTEMPTS TO TRANSMIT SPIROCHAETES BY THE BITES OF *CIMEX LECTULARIUS**

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So soon as it was demonstrated that the African "Tick-fever" was caused by a spirochaete, the possibility that the European "Relapsing Fever" might also be carried by an alternative arthropod host, perhaps the bed-bug, irresistibly suggested itself. Although this possibility has frequently been mentioned, [1, 2, 7] we have seen no records of attempts made to infect experimental animals by the bites of bugs (*Cimex lectularius*) previously fed on infected animals. Tictin speaks of having attempted such experiments, but has not made his results [3] public. We have, therefore, no hesitation in publishing the following experiments, although their results were negative.

The spirochaetes used in our work were of two strains. One was derived from ticks (*Ornithodoros moubata*) brought from the Congo, and is hereinafter spoken of as *Spirochaeta duttoni* [6]; the other was

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kindly given to us by Dr. Charles Norris [4] of New York, and is the same parasite as that used by himself and Novy [5] in their researches, and called by the latter *Spirochaeta obermeieri*. In this paper this strain is called *Spirochaeta obermeieri*.

The bed-bugs used were all caught in or about Liverpool. A few of those used in the experiments made in the autumn of 1905 with *Spirochaeta duttoni* were kept at ordinary room temperature (lowest 5·5° C.), but the great majority were placed in an incubator at 20° C.; this was approximately the average temperature at which ticks had been observed to transmit spirochaetes in the Congo. All the bed-bugs employed were adults, and all were fed frequently, as a rule, every two to four days. Despite the regular temperature and constant food, they died rapidly and failed to reproduce. Towards the end of December, 1905, the experiments were therefore stopped, and it was decided to defer further attempts at transmitting spirochaetes by the bites of bugs until warmer weather commenced. In June, 1906, the experiments were resumed with both *Spirochaeta duttoni* and *Spirochaeta obermeieri*. The freshly caught adult bugs now reproduced freely, and it was therefore possible in this second series of experiments to use both adult and young forms of *Cimex*, as well as bugs coming from eggs laid by parents fed on infected animals. Almost all the bugs used in 1906 have been kept in an incubator at 21° C. It was attempted to keep a few at 37° C., but at this temperature they did badly and died quickly. The bugs used in 1906 were fed less frequently than those experimented with in 1905. As a rule, they were given opportunities to feed only every ten or fifteen days. In 1905 the bugs were nearly always fed in the daytime. In 1906 they were always fed at night (from 9 p.m. to 2 a.m.).

The monkeys (except Experiment 260) employed, were always of a species shown by previous experiments to be susceptible to spirochaetal infection. In two instances (Experiments 258 and 1,295) monkeys which it had been impossible to infect by the bites of bed-bugs were afterwards successfully inoculated with spirochaete-containing blood. Natural immunity of our experimental animals has, therefore, not prevented the success of these experiments. Young monkeys seem to be much more easily infected with spirochaetes than adults. The smallest animals obtainable were therefore used.

The following experiments were done to ascertain whether bed-bugs freshly caught in England were capable of infecting susceptible animals with spirochaetes. Neither were successful.

Experiment 250. September 15th to October 11th, 1905.—In nine days 163 bugs were fed on a very young monkey *Cercopithecus callitrichus* (weight, 1,450 grammes). The temperature remained low, and the blood was uninfected until the animal's death, from other causes, on October 11th.

Experiment 254. September 15th to October 30th, 1905.—From September 23rd to October 6th, 284 bugs were fed on a monkey, *Cercopithecus callitrichus* (weight 1,690 grammes). There were one or two rises of temperature, but the monkey never became infected; it was accidentally killed on October 30th.

Since the main object was to determine whether bed-bugs could transmit spirochaetes under any circumstances the conditions of the experiments were very broad. Bugs were used in several experiments, so that, eventually, many of them had fed at different periods on several animals infected with spirochaetes. The accompanying table indicates the stage of the disease in the infected animals at the moment when bugs were fed upon them (Table I). It also shows the periods, in days, elapsing between this "infecting feed" and the day when the bugs were fed on an uninfected animal for the purpose of transmitting the spirochaetes to it. An examination of this table, and a consideration of what has just been said, will prove that a very thorough attempt has been made to transmit spirochaetes by the bites of bed-bugs.

The temperature of the monkeys on which bed-bugs were fed was taken twice daily, and their blood was examined at least once, often twice, a day. In none of them were spirochaetes ever seen, and in none was there any rise of temperature resembling that produced by spirochaetal infection.

Experiment 258. October 7th, 1905 to August 10th, 1906.—From October 7th to December 20th, 1905, 302 bed-bugs were fed on a young monkey, *Cercopithecus sp.?* (weight, 1,800 grammes). Its blood was examined very frequently, but spirochaetes were never seen. Its temperature which had been slightly irregular became quite normal in February, 1906. On February 22nd, 1906, the monkey was inoculated with 5 ccm. of heavily-infected blood from a European suffering from "African tick fever." Parasites were seen in its blood on the following day, and the disease followed a course, with three relapses, often observed in monkeys. Death followed from general tuberculosis in August, 1906.

Experiment 260. October 25th to November 10th, 1905.—On October 26th and 27th, twenty-five bed-bugs were fed on a young marmoset. Its temperature remained normal, and no spirochaetes were seen in its blood. It died from a perivesical abscess on November 10th.

Experiment 261. October 31st to November 18th, 1905.—From October 31st to November 9th, forty-two bed-bugs were fed on a monkey, *Cercopithecus nictitans* (weight, 2,000 grammes). Its blood was examined daily, but no spirochaetes were seen, although there was one slight rise in temperature to 39·4° C. The animal died November 18th from other causes.

Experiment 264. November 8th to December 25th, 1905.—From November 23rd to December 18th, 128 bugs were fed upon a monkey, *Cercopithecus brazzae* (?) (weight, 1,720 grammes). Spirochaetes were never seen in its blood. The animal died from other causes on December 25th.

Experiment 1,237. July 3rd to September 7th, 1906.—From July 3rd to August 10th, 592 bed-bugs were fed on a young *Macacus rhesus* (weight, 1,390 grammes). Five hundred and sixty-two of the bugs were adults which had previously fed on animals infected with *Spirochaeta duttoni*, thirty were young bugs hatched from eggs laid by females which had previously fed on three occasions, during a period of 2½ months, on animals infected with *Spirochaeta obermeieri*. The monkey never became infected and died of tuberculosis on September 7th, 1906.

Experiment 1,295. August 7th to September 4th, 1906.—From August 7th to August 21st, 1906, 208 bed-bugs were fed on a monkey, *Cercopithecus callitrichus* (weight, 1,685 grammes). Of these bugs 86 had previously fed on animals infected with *Spirochaeta duttoni*; and 122 on animals with *Spirochaeta obermeieri*; sixty-three bugs were fed interruptedly, that is, they were permitted to half fill themselves with blood from an animal infected with *Spirochaeta duttoni*, or *obermeieri*, and were then immediately transferred to this monkey, where they finished feeding. The animal did not become infected; so on September 2nd it was inoculated with blood containing *Spirochaeta duttoni*. Parasites were seen in its blood on September 6th, and it died in the same day. Death was, however, not altogether due to the spirochaetal infection.

Experiment 1,310. August 11th to September 14th, 1906.—From August 11th to September 3rd, 121 bed-bugs were fed upon a *Cercopithecus callitrichus* (weight, 3,000 grammes). One hundred of the bugs had previously fed upon animals infected with *Spirochaeta obermeieri*, 21 on animals with *Spirochaeta duttoni*. The animal is still under observation. Its temperature is normal, and parasites have never been seen in its blood.

Experiment 1,317. August 15th to October 19th, 1906. From August 15th to September 25th, 1906, 345 bed-bugs were fed upon a young *Cercopithecus schmidti* (weight 1,940 grammes). One hundred and one of these bugs were fed interruptedly on this monkey and on an animal infected with *Spirochaeta duttoni*, 108 were young bugs hatched from eggs laid by parents who had fed from one to six weeks, before ovipositing, on animals infected with *Spirochaeta obermeieri*, the remainder were immature and adult bugs which had previously fed on animals infected with either spirochaete.

It will be noticed that only comparatively few bed-bugs hatched from parents previously fed on infected animals were fed on Experiments 1,237 and 1,317. More attention was not paid to the possible transmission of the spirochaetes by the second generation of bugs, because of the history of epidemics of relapsing fevers in which succeeding cases followed the introduction of a first case in a period rather too short to permit of the hatching of eggs laid by parents which had been fed upon the first case.

Tictin 3 reports that a second case was found in 1½ weeks after the arrival of a first case. The incubation period in relapsing fever is about one week. The second case must, therefore, have received his infection within a week of the arrival of the first case, but from seven to ten days are required for the development of the eggs of *Cimex lectularius*. It is, therefore, improbable that the second case was infected by the progeny of bugs which had previously fed on the first case.

We conclude from these observations that *Cimex lectularius* **is probably* unable to transmit** *Spirochaeta duttoni* **or** *Spirochaeta obermeieri*, **and, therefore, that it cannot be an important factor in the causation of epidemics of relapsing fever.**

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* When these experiments were first commenced a positive result was obtained in one instance. Bed-bugs have been since fed on susceptible monkeys under exactly the same conditions, but we have never been able to infect another animal. We are forced to conclude that the technique employed was in this instance at fault. It is very probable that this is so, since, when this "successful" experiment was done, laboratory servants did the feeding and, in error, they may have allowed infected ticks to feed on this animal. In the later experiments the feeding was done by ourselves. Karlinski 7 and others have suggested that *Spirochaeta obermeieri* may be transmitted by fleas or lice. Series of experiments similar to those detailed above have already been commenced in these laboratories with *Pediculi capitis* and *vestimentorum* and *Pulex*.

STAGE OF THE DISEASE IN THE ANIMAL INFECTED WITH SPIROCHAETES.

Stage of the disease	Spirochaete	Parasites	The number of days elapsing between the infecting and transmitting feeds	Interrupted feeding. Number of bed-bugs fed on both animals
Commencement of attack; parasites appearing in the peripheral circulation; temperature rising.	African Spirochaete	Parasites present	2, 3, 4, 5, 6, 8, 10, 14, 15, 17, 18, 20, 21, 26	
	New York Spirochaete	Parasites present	5, 10, 11, 12, 13, 16, 22, 26, 27, 30, 32, 33, 34, 35, 38, 47, 48, 50, 52, 53, 54, 55, 58, 70	
Middle of attack; numerous parasites in the peripheral blood; temperature high.	African Spirochaete	Parasites present	1, 2, 3, 4, 6, 7, 8, 13, 16, 22, 27, 31	35 40 36
		Parasites not seen	2, 4, 28	
	New York Spirochaete	Parasites present	6, 13, 16, 26, 33, 39, 43, 47, 53, 54, 63, 64	
End of attack; parasites disappearing or just gone from the peripheral circulation; temperature falling.	African Spirochaete	Parasites present	4, 10, 20, 24, 27, 29, 31, 33, 37	26
		Parasites not seen	3, 9, 19, 23, 26, 28, 30, 32, 36	
	New York Spirochaete	Parasites present	2, 4, 8, 10, 14, 15, 21, 24, 30, 31, 38, 41, 42, 51, 53, 63, 68	27
Interval between attacks; no parasites in the peripheral blood; temperature low.	African Spirochaete		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 21, 22, 26, 29, 31, 55, 70, 81	
	New York Spirochaete			

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